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VOLUME IV

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1960

No. 501

BINKS MANUFACTURING CO.,
PETITIONER,

vs.

RANSBURG ELECTRO-COATING CORPORATION.

ON WRIT OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS
FOR THE SEVENTH CIRCUIT

PETITION FOR CERTIORARI FILED OCTOBER 24, 1960

CERTIORARI GRANTED DECEMBER 19, 1960

SUPREME COURT OF THE UNITED STATES

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Number	*Issued*	*Title*		
RE20,660	Feb. 22, 1938	Method of Coating and Apparatus Therefor and Product	536	533
2027087	Jan. 7, 1936	Abrasive Sheet and Process of Making the Same	548	545

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Number	*Issued*	*Title*	
2027308	Jan. 7, 1936	Manufacture of Abrasive Articles	551	548
2027309	Jan. 7, 1936	Abrasive Material	554	551
2082182	June 1, 1937	Manufacture of Abrasive Articles	562	559
2245301	June 10, 1941	Manufacture of Abrasive Articles	565	562
2279361	April 14, 1942	Electrostatic Coating Process	569	566
2287837	June 30, 1942	Method and Apparatus for Applying Coating Materials	574	571
2318570	May 4, 1943	Manufacture of Abrasives	584	581
2318571	May 4, 1943	Manufacture of Abrasives	600	597
2328577	Sept. 7, 1943	Process and Apparatus for Grading and for Coating with Comminuted Materials	614	611
2376342	May 22, 1945	Manufacture of Abrasives	625	622
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Number	*Issued*	*Title*	
1854071	April 12, 1932	Method of Manufacturing Abrasives	652	649
2047525	July 14, 1936	Insulating Method for Electrical and Thermo-Technical Purposes, and Apparatus for Accomplishing the Same	657	654

			Original	Print
Record from the United States District Court for the Southern District of Indiana, Indianapolis Division—Continued				
Defendant's Exhibit 21—United States Letters Patent—Continued				
Number	*Issued*	*Title*		
2087260	July 20, 1937	Homogenous Piled Surface	662	659
2152077	March 28, 1939	Production of Piled Surfaces in Pattern Form	666	663
2166385	July 18, 1939	Determining Electrical Characteristics	676	673
2173032	Sept. 12, 1939	Production of Pile Surfaced Materials	680	677
2173078	Sept. 12, 1939	Production of Piled Surfaces	690	687
2174328	Sept. 26, 1939	Piled Surface in Pattern Form	697	694
2217126	Oct. 8, 1940	Piled Surface in Pattern Form	702	699
2218445	Oct. 15, 1940	Production of Pile Surface Materials	711	708
2222539	Nov. 19, 1940	Method of and Apparatus for Making Pile-Surfaced Sheets	715	712
2223476	Dec. 3, 1940	Method for Making Pile Fabrics	721	718
2231324	Feb. 11, 1941	Apparatus for and Method of Making Hat Bats	728	725
2248064	July 8, 1941	Coating, Particularly for Manufacture of Abrasives	732	729
2248853	July 8, 1941	Abrasive Article and Method of Making Same	748	745
2281558	May 5, 1942	Manufacture of Abrasive Articles and Apparatus Therefor	763	760
2356489	Aug. 22, 1944	Apparatus for Coating	774	771
2370636	March 6, 1945	Manufacture of Abrasives	787	784
2371605	March 20, 1945	Coating, Particularly for Manufacture of Abrasives	800	797
2376343	May 22, 1945	Manufacture of Abrasives	815	812
2376922	May 29, 1945	Method of and Apparatus for Making Pile Fabrics	824	821
2447374	Aug. 17, 1948	Method of Applying Coating Materials	833	830
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[fol. 511] [File endorsement omitted]

12737

IN THE UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF INDIANA

INDIANAPOLIS DIVISION

No. IP 56-C-262

BINKS MANUFACTURING COMPANY, Plaintiff,

vs.

RANSBURG ELECTRO-COATING CORPORATION, Defendant.

Before the

HON. CALE J. HOLDER

[fol. 512]

Transcript of Testimony—December 19, 1958

Indianapolis, Indiana
December 19, 1958
9:50 o'clock, A. M.

(The Court met pursuant to adjournment and the trial was resumed as follows:)

• • • • • • •

[fol. 513] Redirect Examination of Mr. Miller.

Questions by Mr. Hume:

• • • • • • •

Q. Now, in answer to one of Mr. Meroni's questions, with respect to the character of the defendant's Exhibit No. 2, commercial system, using the rotary heads, for instance, as exemplified by Exhibit 17-B, you stated in answer to one of his questions that something more than electrostatic force was needed to paint in this system, and he made reference to the rotation of centrifugal force of the head.

Is your answer there in any way— Does it modify in any way your previous statement that the electrostatic field effects the atomization, dispersion, and deposition?

Mr. Meroni: Objected to as leading. He is attempting to get the witness to change his testimony in a leading question, your Honor.

The Court: The objection will be overruled.

A. It does not, sir. My understanding is that the rotation is necessary for carrying or feeding the coating material from the source to the site of atomization.

[fol. 514]

IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA,
INDIANAPOLIS DIVISION

Plaintiff's Exhibit IIIII.

IN THE UNITED STATES DISTRICT COURT.
For the District of Massachusetts.

United States of America, *Plaintiff*, *vs.* Minnesota Mining and Manufacturing Company, Behr-Manning Corporation, The Carborundum Company, Armour and Company, Durex Abrasives Corporation and The Durex Corporation, *Defendants.*	Civil Action No. 8119

FINAL JUDGMENT AS TO COUNT ONE.

The plaintiff, United States of America, having filed its amended complaint herein on July 5, 1949; the defendants having appeared and filed their separate answers to Count

One of the amended complaint denying any violation of law; Count Two of the amended complaint having been tried and final judgment having been entered thereon on September 13, 1950; and the plaintiff and said defendants, by their respective attorneys herein, having severally consented to the entry of this Final Judgment as to Count One without trial or adjudication of any issue of fact or law herein, and without admission by any party in respect of any such issue,

Now, Therefore, before any testimony or evidence has been taken herein, and without trial or adjudication of any issue of fact or law herein, and upon consent as aforesaid of all of the parties hereto,

[fol. 515] It Is Hereby Ordered, Adjudged and Decreed, as to Count One of the amended complaint as follows:

I.

This Court has jurisdiction of the subject matter hereof and of all parties hereto. Count One of the amended complaint states a cause of action against the defendants under Sections 1 and 2 of the Act of Congress of July 2, 1890, entitled "An Act to Protect Trade and Commerce against Unlawful Restraints and Monopolies," as amended.

II.

For purposes of this judgment,

A. "Minnesota" means the defendant Minnesota Mining and Manufacturing Company, a corporation organized and existing under the laws of the State of Delaware;

B. "Behr-Manning" means the defendant Behr-Manning Corporation, a corporation organized and existing under the laws of the State of Massachusetts;

C. "Carborundum" means the defendant The Carborundum Company, a corporation organized and existing under the laws of the State of Delaware;

D. "Armour" means the defendant Armour and Company, a corporation organized and existing under the laws of the State of Illinois;

E. "Defendants" means Minnesota, Behr-Manning, Carborundum and Armour;

F. "Coated Abrasive Products" means any non-rigid abrasive or polishing article which comprises a flexible sheet or sheetlike backing to one or both [fol. 516] surfaces of which there is attached by an adhesive a coating of one or more layers of abrasive or polishing grain, including rigid or non-rigid abrading or polishing articles made therefrom to be used for abrading or polishing purposes;

G. "Defined Patents" means United States letters patent, patent applications and rights under letters patent, as follows:

(1) all letters patent, rights under letters patent, and applications for letters patent, now owned or controlled by any of the defendants, and all letters patent which may issue on or result from said applications,

(2) all letters patent, rights under letters patent, and applications for letters patent, issued to, acquired, or filed by, any of the defendants during the five years following the date of the entry of this judgment, and all letters patent which may issue on or result from said applications,

(3) all divisions, continuances, reissues, or extensions of the patents and applications described above in clauses (1) and (2),

relating to Coated Abrasive Products and any method, material, equipment or process involved in the production or manufacture of Coated Abrasive Products.

III.

The provisions of this judgment applicable to any defendant shall apply to such defendant, its successors, subsidiaries, assigns, officers, directors, agents, employees and all

other persons acting or claiming to act under, through or for such defendant.

[fol. 517] IV.

Each of the patent license and cross license agreements relating in whole or in part to Coated Abrasive Products or any method, material, equipment or process involved in the production or manufacture of Coated Abrasive Products, to which any of the defendants is presently a party as licensor, including, but without limitation, the following agreements, is hereby terminated and canceled in its entirety; and each of the defendants is hereby enjoined and restrained from the further performance or enforcement of any of said agreements, or from entering into, adopting, adhering to, or furthering any agreement, arrangement, or course of conduct for the purpose or with the effect of maintaining, reviving or reinstating any of said agreements:

A. the Patent License Agreements Relating to Waterproof Sandpaper, dated as of June 1, 1949, between Minnesota, as licensor, and Armour, Behr-Manning, and Carborundum, as licensees, respectively;

B. the Patent License Agreements Relating to Electrocoated Sandpaper between Behr-Manning, as licensor, and

(1) Minnesota, as licensee, dated September 19, 1932,

(2) Armour, as licensee, dated October 13, 1932, and

(3) Carborundum, as licensee, dated January 11, 1933,

each as amended by letter dated May 19, 1948;

C. the licenses granted by the Spraying Agreement dated December 6, 1935 between Armour, Behr-Manning, Carborundum and Minnesota;

[fol. 518] D. the licenses granted by the Mechanical Orienting Agreement dated March 6, 1936 between

Armour, Behr-Manning, Carborundum and Minnesota;

E. the Cross License Agreements dated as of March 17, 1943, as modified as of October 1, 1945, by and between Minnesota and Armour, Minnesota and Behr-Manning and Minnesota and Carborundum, Armour and Behr-Manning, Armour and Carborundum, and Behr-Manning and Carborundum, respectively;

F. the license agreements entered into by the defendants pursuant to said Cross License Agreements, as follows:

(1) the Adhesive Treatment License Agreements between Behr-Manning, as licensor, and

(a) Armour and Minnesota, as licensees, respectively, dated January 1, 1944,

(b) Carborundum, as licensee, dated May 1, 1945,

(c) Midwest Abrasive Company, as licensee, dated September 12, 1946;

(2) the license agreements under United States Letters Patent No. 2,358,724, dated as of January 1, 1945, between Behr-Manning, as licensor, and Armour, Carborundum and Minnesota, as licensees, respectively;

(3) the license agreements under United States Letters Patent No. 2,286,208, between Carborundum, as licensor, and

(a) Minnesota, as licensee, dated August 1, 1949,

[fol. 519] (b) Armour, as licensee, dated February 1, 1950, and

(c) Behr-Manning, as licensee, dated August 1, 1949,

(4) the license agreements under United States Letters Patent No. 2,430,099 between Carborundum, as licensor, and

(a) Minnesota, as licensee, dated November 1, 1948,

(b) Armour, as licensee, dated March 23, 1950,

(c) Behr-Manning, as licensee, dated November 1, 1948; and

(d) Mid-West Abrasive Company, as licensee, dated March 24, 1950;

(5) the license agreements under United States Letters Patent No. 2,391,731 between Minnesota, as licensor, and

(a) Carborundum, as licensee, dated August 1, 1946, and

(b) Behr-Manning, as licensee, dated September 1, 1948, and

(6) the license agreements under United States Letters Patent Nos. 2,184,896, 2,302,711 and 2,333,035, dated as of October 1, 1945, between Behr-Manning, as licensor, and Armour and Carborundum, as licensees, respectively.

[fol. 520] V.

Each defendant is hereby ordered and directed:

A. In so far as it now has or may acquire the power or authority to do so, to issue to any applicant (including any other defendant) making written request therefor a non-exclusive and unrestricted license or sublicense to make, use and vend Coated Abrasive Products under any, some or all of the Defined Patents, including those presently owned or controlled by defendants as listed in Schedule "A" attached hereto, without any condition or restriction whatsoever, except that:

(1) a reasonable and non-discriminatory royalty may be charged and collected;

(2) reasonable provision may be made for periodic inspection of the books and records of the licensee by an independent auditor who may report to the defendant licensor only the amount of the royalty due and payable and no other information;

(3) the license may be non-transferable;

(4) reasonable provision may be made for cancellation of the license upon failure of the licensee to pay the royalties or to permit the inspection of its books and records as provided in Paragraph A of this Section V;

(5) the license must provide that the licensee may cancel the license at any time by giving thirty (30) days' notice in writing to the licensor.

B. Within thirty (30) days after the date of application, issuance or acquisition of any of the Defined Patents, to advise this Court and the At-[fol. 521] torney General, in writing, of the number and date of such application, issuance or acquisition.

C. Upon any application for a license in accordance with the provisions of Paragraph A of this Section V, the defendant to whom such application is made shall advise the applicant of the royalty it deems reasonable for the Defined Patent or Patents to which the application pertains. If the defendant and the applicant are unable to agree upon what constitutes a reasonable royalty, the defendant may apply to this Court for a determination of a reasonable royalty, giving notice thereof to the applicant and the Attorney General, and shall make such application forthwith upon request of the applicant. In any such proceeding the burden of proof shall be upon the defendant to whom application is made to establish, by a fair preponderance of evidence, a reasonable royalty, and the Attorney

General shall have the right to be heard thereon. Pending the completion of any such court proceeding, the applicant shall have the right to make, use and vend under the Defined Patent or Patents to which its application pertains, without the payment of royalty or other compensation, but subject to the following provisions: Such defendant may, with notice to the Attorney General, apply to the Court to fix an interim royalty rate pending final determination of what constitutes a reasonable royalty. If the Court fixes such interim royalty rate, a license shall then issue providing for the periodic payment of royalties at such interim rate from the date of the making of such application by the applicant; [fol. 522] and whether or not such interim rate is fixed, any final order may provide for such readjustments including retroactive or diminished royalties as the Court may order after final determination of a reasonable and non-discriminatory royalty.

D. Each license granted pursuant to this Section V shall provide that the licensee may at any time, without revoking or surrendering its license, dispute the validity, scope or enforceability of any of the patents under which the license is granted, and this judgment shall not be construed as importing any validity or value to any of such patents.

VI.

Each defendant is hereby enjoined and restrained from:

A. Making any disposition of any of the Defined Patents which deprives it of the power or authority to issue licenses or sublicenses required by Paragraph A of Section V unless it sells, transfers or assigns such Defined Patents and requires, as a condition of such sale, transfer or assignment that the purchaser, transferee, or assignee thereof shall observe the provisions of Section V of this judgment with respect to the Defined Patents so acquired and the purchaser, transferee or assignee shall file with this Court, prior to the consummation of said transac-

tion, an undertaking to be bound by the provisions of Section V of this judgment with respect to the Defined Patents so acquired.

B. Acquiring any license, sublicense, grant of immunity or similar right under any Defined Patent to make, use and vend Coated Abrasive Products, [fol. 523] unless such license, sublicense, grant of immunity or similar right is non-exclusive and contains a provision that throughout its life the licensor will make available an equivalent license, sublicense, grant of immunity or similar right to any third person requesting the same, on terms and conditions at least as favorable as those accorded to said defendant.

VII.

Each defendant is hereby ordered and directed, on written request, to furnish to any licensee at the time of granting a license under Paragraph A of Section V of this judgment, upon payment of a purely nominal charge therefor, a written manual or manuals describing all the methods, processes, materials and equipment then currently used by it in commercial production or manufacture under the Defined Patents under which such applicant is licensed. Any such manual or manuals so furnished to a licensee shall be made available to all prior licensees under the same Defined Patents, excepting the other defendants herein. In the event any such licensee shall find the information set forth in any such manual inadequate to enable successful utilization by that licensee of any of the methods, processes, materials or equipment described therein, and such licensee shall so inform in writing the defendant concerned, then such defendant is ordered and directed to furnish promptly, at the actual cost thereof to the defendant, such additional written information or technical assistance as shall be reasonably necessary to the successful utilization thereof. Any such additional written information shall be made available to all other licensees under the same Defined Patents, excepting the other defendants herein.

[fol. 524]

VIII.

Subject to the provisions of Section VII of this judgment, each defendant is hereby enjoined and restrained from furnishing to any other defendant technical information relating to the production or manufacture of Coated Abrasive Products or methods, equipment, materials and processes to be used in the manufacture thereof, unless it furnishes such technical information to any other manufacturer of Coated Abrasive Products upon reasonable and non-discriminatory terms and conditions.

IX.

Each defendant is hereby enjoined and restrained from entering into, adhering to, maintaining or furthering any combination, conspiracy, contract, agreement, understanding, plan or program, directly or indirectly, with any other manufacturer of Coated Abrasive Products:

A. To fix, maintain, stabilize, determine or adhere to prices, discounts, customer classifications or other terms or conditions for the sale of Coated Abrasive Products;

B. To limit, restrict, prevent or restrain any manufacturer of Coated Abrasive Products from making or selling any kinds, types, sizes, styles, or grades of Coated Abrasive Products, or from manufacturing or producing any Coated Abrasive Products according to any standards or specifications;

[fol. 525]

X.

Nothing contained herein shall be deemed to adjudicate, determine, or affect the legality or illegality of any agreement involving relationships solely between:

A. A defendant and its subsidiaries;

B. A defendant or its subsidiaries and its parent;

C. Subsidiaries of any defendant and their subsidiaries.

XI.

For the purpose of securing compliance with this judgment and for no other purpose, duly authorized representatives of the Department of Justice shall, upon written request of the Attorney General, or an Assistant Attorney General, and on reasonable notice to any defendant, made to its principal office, be permitted subject to any legally recognized privilege, (1) access during the office hours of said defendant to all books, ledgers, accounts, correspondence, memoranda, and other records and documents in the possession or under the control of said defendant relating to any matters contained in this judgment, and (2) subject to the reasonable convenience of said defendant and without restraint or interference from it to interview officers or employees of said defendant, who may have counsel present, regarding any such matters, and (3) upon request the defendant shall submit such reports in writing to the Department of Justice with respect to matters contained in this judgment as may from time to time be necessary to the enforcement of this judgment. No information obtained by the means provided in this Section XI shall be divulged by any representative of the Department of Justice to any person other than a duly authorized representative of such Department, except in the course of legal pro- [fol. 526] ceedings to which the United States is a party for the purpose of securing compliance with this judgment or as otherwise required by law.

XII.

Jurisdiction is retained for the purpose of enabling any of the parties to this judgment to apply to this Court at any time for such further orders and directions as may be necessary or appropriate for the construction or carrying out of this judgment or for the modification or termination of any of the provisions thereof, and for the purpose of the enforcement of compliance therewith and the punishment of violations thereof.

Dated: Boston, Mass.
November 6, 1950.

Myzanski,
United States District Judge.

Schedule "A".

[fol. 527]

Defined Patents Owned or Controlled by the Defendants.

Patent No.	Dated	Inventor/s
Armour and Company Patents:		
1,991,645	Feb. 19, 1935	Woodward
1,994,263	Mar. 12, 1935	Woodward
2,050,212	Aug. 4, 1936	Rizor
2,347,244	Apr. 25, 1944	Colt
Behr-Manning Corporation Patents:		
1,987,467	Jan. 8, 1935	Crupi
2,027,087	Jan. 7, 1936	Buckner
Reissue 20,660) Original 2,027,307)	Jan. 7, 1936	Schacht
2,027,308	Jan. 7, 1936	Schacht
2,027,309	Jan. 7, 1936	Schacht
2,082,182	June 1, 1937	Schacht
Reissue 21,852) Original 2,123,581)	July 12, 1938	Anderson
2,124,055	July 19, 1938	Courtney
2,130,753	Sept. 20, 1938	Baker
2,136,150	Nov. 8, 1938	Oglesby
2,173,129	Sept. 19, 1939	Oglesby
2,173,130	Sept. 19, 1939	Oglesby
2,173,796	Sept. 19, 1939	Oglesby
2,175,073	Oct. 3, 1939	Amstuz
2,184,896	Dec. 26, 1939	Oglesby
2,197,741	Apr. 16, 1940	Boucher
2,198,766	Apr. 30, 1940	Gallagher
2,199,752	May 7, 1940	Oglesby
2,209,715	July 30, 1940	Crupi
2,209,716	July 30, 1940	Crupi

Patent No.	Dated	Inventor/s
2,217,247	Oct. 8, 1940	(Walker (Burns
2,217,525	Oct. 8, 1940	Oglesby
2,239,828	Apr. 29, 1941	Oglesby
[fol. 528]		
2,245,301	June 10, 1941	Schacht
2,279,361	Apr. 14, 1942	Amstuz
2,287,837	June 30, 1942	Smyser
2,288,624	July 7, 1942	Holmsten
2,288,625	July 7, 1942	Holmsten
2,292,991	Aug. 11, 1942	Crompton
2,294,064	Aug. 25, 1942	Amstuz
2,302,711	July 24, 1942	(Oglesby (Strain
2,305,157	Dec. 15, 1942	Ham
2,307,232	Jan. 5, 1943	Oglesby
2,318,570	May 4, 1943	Carlton
2,318,571	May 4, 1943	Carlton
2,322,156	June 15, 1943	Oglesby
2,328,577	Sept. 7, 1943	Oglesby
2,333,034	Oct. 26, 1943	(Oglesby (Reilly (Gilbert
2,333,035	Oct. 26, 1943	Oglesby
2,339,208	Jan. 11, 1944	Ban der Pyl
2,358,724	Sept. 19, 1944	Manchester
2,370,636	Mar. 6, 1945	Carlton
2,375,813	May 16, 1945	Oglesby
2,375,814	May 15, 1945	Oglesby
2,376,342	May 22, 1945	Carlton
2,376,343	May 22, 1945	Carlton
2,403,018	July 2, 1946	Oglesby
2,456,985	Dec. 21, 1948	Oglesby
2,463,241	Mar. 1, 1949	Carlton

Patent No.	Dated	Inventor/s
2,463,242	Mar. 1, 1949	Carlton
2,485,765	Oct. 25, 1949	Oglesby
Behr-Manning Corporation Patent Applications:		
733,614	Mar. 10, 1947	Waterfield
761,750	July 18, 1947	(Webber (Timmer

[fol. 529]

The Carborundum Company Patents:

1,941,962	Jan. 2, 1934	Tone
1,944,898	Jan. 30, 1934	McKee
1,988,065	Jan. 15, 1935	Wooddell
1,989,742	Feb. 5, 1935	Davis
1,994,283	Mar. 12, 1935	Martin
2,015,658	Oct. 1, 1935	Bazzenberger
2,033,991	Mar. 17, 1936	(Melton (Benner
2,035,521	Mar. 31, 1936	(Benner (Melton (Kirchner
2,049,535	Aug. 4, 1936	(Benner (Kirchner (Melton
2,050,992	Aug. 11, 1936	Aust
2,053,360	Sept. 8, 1936	(Benner (Melton
2,053,361	Sept. 8, 1936	(Benner (Melton
2,059,583	Nov. 3, 1936	(Jackson (Kirchner
2,071,549	Feb. 23, 1937	Mahlman
Reissue 21,552) Original 2,078,831)	Apr. 27, 1937	(Benner (Melton

Patent No.	Dated	Inventor/s
2,082,916	June 8, 1937	Stratford
2,097,806	Nov. 2, 1937	Weidrich
2,108,645	Feb. 15, 1938	Bryant
2,111,006	Mar. 15, 1938	Robie
2,111,272	Mar. 15, 1938	Paulson
2,115,904	May 3, 1938	Bryant
2,124,666	July 26, 1938	(Benner (Melton
2,128,905	Sept. 6, 1938	(Benner (Melton
2,128,906	Sept. 6, 1938	(Benner (Melton
2,128,907	Sept. 6, 1938	(Benner (Melton
[fol. 530]		
2,128,966	Sept. 6, 1938	Robie
2,129,661	Sept. 13, 1938	Ball
2,129,954	Sept. 13, 1938	(Martin (Upper (Aust
2,130,194	Sept. 13, 1938	Robie
2,138,882	Dec. 6, 1938	Robie
2,141,658	Dec. 27, 1938	(Melton (Benner (Kirchner
2,152,392	Mar. 28, 1939	Tone
2,179,487	Nov. 14, 1939	(Benner (Robie
2,184,348	Dec. 26, 1939	(Kirchner (Melton (Benner
2,187,624	Jan. 16, 1940	(Melton (Benner (Kirchner

Patent No.	Dated	Inventor/s
2,187,743	Jan. 23, 1940	(Kirchner (Wooddell
2,191,827	Feb. 27, 1940	(Benner (Melton
2,194,253	Mar. 19, 1940	(Benner (Melton (Kirchner
2,194,472	Mar. 26, 1940	Jackson
2,201,194	May 21, 1940	(Melton (Benner (Kirchner
2,201,195	May 21, 1940	(Melton (Benner (Kirchner
2,201,196	May 21, 1940	Williamson
2,205,276	June 18, 1940	Robie
2,209,059	July 23, 1940	Kirchner
2,209,074	July 23, 1940	Dahlstrom
2,215,210	Sept. 17, 1940	Dahlstrom
2,219,853	Oct. 29, 1940	Tone
[fol. 531]		
2,223,392	Dec. 3, 1940	Smith
2,224,009	Dec. 3, 1940	Aust
2,225,877	Dec. 24, 1940	(Melton (Kirchner
2,225,937	Dec. 24, 1940	Williamson
2,227,200	Dec. 31, 1940	Robie
2,229,490	Jan. 21, 1941	(Benner (Melton (Kirchner
2,233,175	Feb. 25, 1941	(Melton (Benner
2,250,119	July 22, 1941	Williamson
2,252,587	Aug. 12, 1941	(Tone (Martin

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IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA
INDIANAPOLIS DIVISION

DEVILBISS MANUFACTURING CO.
v.
RANSBURG ELECTRO-COATING CORP.
CIVIL ACTION
NO. IP 56-C-362

Feb. 22, 1938. **Plaintiff's Exhibit No. JJJJJ** Re. 20,660

METHOD OF COATING AND APPARATUS THEREFOR AND PRODUCT

Original Filed July 30, 1928 3 Sheets-Sheet 1

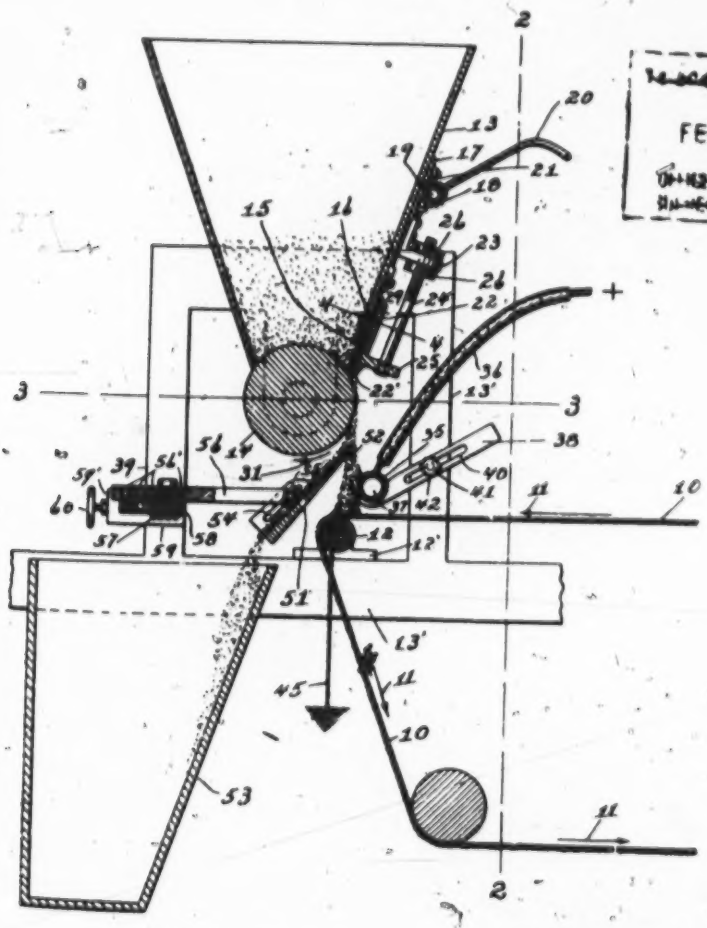

Fig. 1.

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Feb. 22, 1938. E. C. SCHACHT Re. 20,660

METHOD OF COATING AND APPARATUS THEREFOR AND PRODUCT

Original Filed July 30, 1928 3 Sheets-Sheet 2

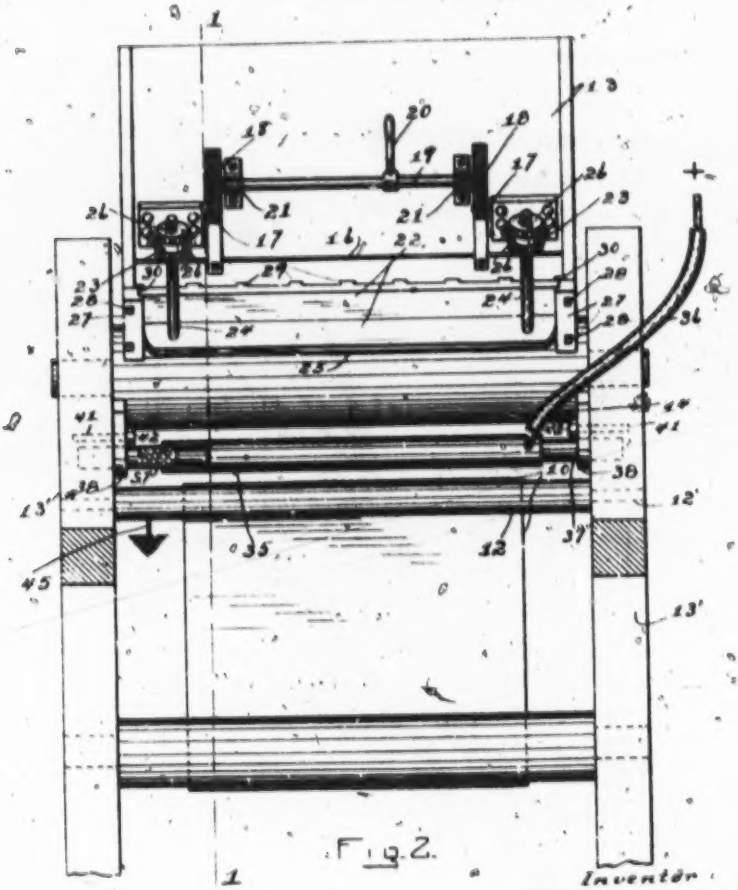

FIG. 2.

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[fol. 538]

Feb. 22, 1938. E. C. SCHACHT Re. 20,680

METHOD OF COATING AND APPARATUS THEREFOR AND PRODUCT

Original Filed July 30, 1930 3 Sheets-Sheet 3

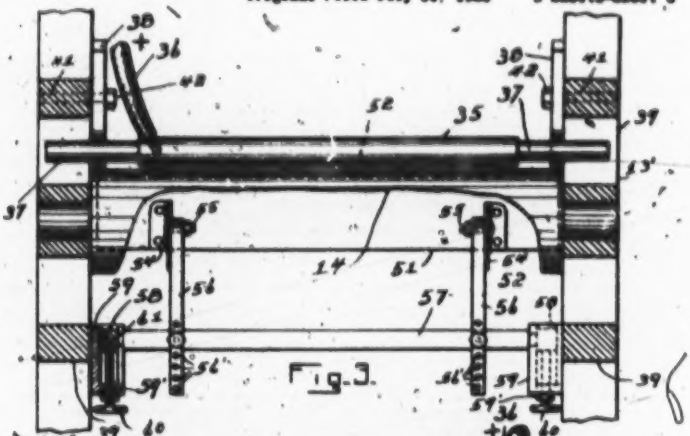

Fig. 3.

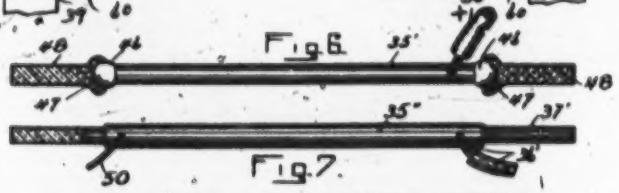

Fig. 6.

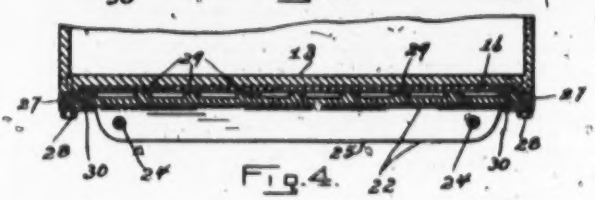

Fig. 7.

Fig. 4.

Fig. 5.

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Released Feb. 22, 1938

Re. 20,660

UNITED STATES PATENT OFFICE

20,660

METHOD OF COATING AND APPARATUS THEREFOR AND PRODUCT

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Original No. 2,057,597, dated January 7, 1936, Serial No. 706,353, July 30, 1933. Application for reissue December 21, 1937, Serial No. 180,697

45 Claims. (Cl. 91—68)

This invention relates to the art of coating with finely divided or fragmentary material.

An object of the invention is to provide an improved method for coating with such material and an apparatus for carrying out the method.

The invention seeks to provide an improved method for controlling the arrangement or distribution of the particles upon the surface to be coated.

The invention contemplates an arrangement or distribution control which will effect proper distribution or dispersion of the particles with reference to one another, and preferably also the proper positioning or orientation of each individual particle, so that in providing a coated surface of abrasive material, for instance, the particles have their major axes substantially perpendicular to the carrier or to the abrasive surface whereby the sharpest portion of each particle will be exposed with the major axes of the particles disposed substantially perpendicularly to the surface of the carrier.

The method and apparatus will be described in their application to the manufacture of an abrasive paper, such as sand paper, although it will be understood that while particularly useful in the manufacture of such material, the invention is not limited in broader aspects to this particular field.

Abrasive paper, by which is meant any abrasive sheet or strip material having an abrasive surface, such as sand, ordinarily consists of a backing or carrier of paper or fabric, or combined paper and fabric, which is first provided with an adhesive surface upon which the abrasive or cutting material, such as sand, is then deposited.

Abrasive paper is of two general types. In one type, the adhesive surface of the carrier or backing is completely covered with the abrasive grains or fragments. The individual grains are closely packed, so that virtually no portion of the backing surface is exposed. Such a coating of abrasive material is commonly called a "closed coating."

In the second type, the individual particles or grains are spaced apart as uniformly as possible over the surface, so that each grain stands by itself or alone as a unit of the abrasive surface. Such a coating of abrasive material is termed an "open coating".

The open coating is considered preferable for abrasive paper in some usages, since it does not tend to load or become packed with the material which is abraded. In some cases, a closed coating, in which the interstices between the individual grains are extremely small, and virtually non-existent, quickly becomes loaded or embedded with the material abraded, and this results in excessive friction and finally the burning of both the abrasive and abraded surfaces. Such loading and burning is especially noticeable when abrading soft materials or materials of a gummy or resinous nature. The open coating overcomes this objection, since in view of the substantial space around each of the abrasive grains, the abrasive surface does not become packed, and the particles removed from an abraded object do not remain in the interstices between the individual grains.

In the manufacture of both types of coating, it is preferable to arrange or orient the individual grains so that their major axes are substantially perpendicular to the carrier with the result that their sharper and more pointed portions are exposed. Furthermore, in the formation of an open coating, it has always been a problem to obtain the desired arrangement or dispersion of the individual grains with reference to one another. This dispersion or spacing of the individual particles is a problem particularly important in the formation of an open coating, but the proper distribution of the particles as they are deposited upon the carrier is also important in the manufacture of a closed coating. In the manufacture of the closed coating, it is customary to drop or deposit upon the adhesively coated carrier a greater amount of abrasive than it can hold. The surplus is then removed. Consequently, the only control as to the amount of abrasive retained is the holding capacity of the adhesive. In order to control accurately the amount of abrasive applied on a closed coating, it is, therefore, important to see that the surface is uniformly covered, and due to this it is necessary that the particles be uniformly distributed at the instant the abrasive is applied to the adhesive. When the particles are simply dropped on the adhesively coated carrier and no dispersing method employed, the resultant surface reflects any irregularities which are present in the fall or passage of the sand, and these irregularities produce streaks or ridges in the coating. It has also been found that there is a tendency in dropping sand or other abrasive particles for the latter to bunch together and produce what is called a lumpy or bunchy coating which greatly impair the cutting efficiency of the sheet because there are created a multiplicity of small high

[fol. 540]

areas which come in contact with the surface to be abraded. Obviously, these areas keep much of the abrasive out of contact with the surface being abraded, and thus reduce the efficiency of the sheet.

It will be understood, therefore, that by the terms "dispersion" or "arrangement", as applied to the particles, is not meant any particular spacing of the particles relative to one another, since the particles are "dispersed" or "arranged" relative to one another regardless of whether an open or closed coating is being formed. So far as the method of this invention is concerned, the difference between an open and closed coating resides solely in the extent or degree to which the electrostatic field is used, i. e., a stronger field or different disposition of the same is employed to produce an open coating than a closed coating. But in the manufacture of both types of coating the electrostatic field may be effectively employed to produce the desired arrangement or dispersion of particles in the abrasive stream.

Heretofore, it has been the common practice to supply the abrasive material, such as sand, from a hopper by means of a feed roll having associated therewith an adjustable gate which controls the feed of sand. In the use of coarser grades of sand or abrasive material, such a means for controlling its application has been found to be effective, to a certain extent, since coarse particles will not bind or pack between the gate and the feed roll and will flow uniformly [illegible] gate and roll to produce an open [illegible] the carrier. However, it has been observed that this expedient does not effectively guarantee the uniformity of particle distribution or the equalization of density throughout the different areas, and, moreover, it has no effect upon the sharpness of the abrasive surface produced, and does not have a tendency to arrange each individual particle so that its sharpest portion or point is exposed.

In the use of fine abrasive material, such as number 240 sand, a feed gate and roll or similar apparatus does not produce a uniform flow, even though the gate and feed roll surfaces are finely ground and brought extremely close together. The difficulty is particularly due to the tendency of the sand to pack or bind in the gate. As a result, the abrasive surface is characterized by bare spots, bleaches, bars and streaks.

Consequently, in the manufacture of abrasive paper from fine abrasive material, it is necessary to exercise extreme care to obtain a uniform flow of sand and to finely grind and adjust both the gate and feed roll.

The present invention seeks to provide an improved means for obtaining proper arrangement of the sand both with respect to the uniform dispersion or spacing of the particles relative to one another, and also with respect to the arrangement or orientation of each particle considered individually to expose its sharpest portion.

The invention also contemplates an improved apparatus for carrying out this method.

Essentially, the invention comprises the use of an electrical charge produced by an electrostatic field, which is arranged so as to influence the individual sand particles to obtain the proper distribution of the same over the surface, and also preferably to position or "orient" each particle so that its major axis is substantially at right angles to the abrasive surface whereby the sharpest and therefore most effective abrasive portion is exposed.

The invention also contemplates the use of the electrical field in such a manner that the stream of abrasive particles, as it flows toward the carrier, is controlled by the electrical field so as to cause a uniform distribution of the same relatively to one another, and thus produce a misting of the particles over a much greater area and eliminate ridges and streaks as well as the bunchiness or humping in the coating.

In providing the electrostatic field, the invention seeks to dispense with the necessity for accurately grinding and spacing the gate and feed roll. It has been found preferable to dispose the field so that it will affect the sand as it travels under the influence of a uni-directional force, such as gravity, which propels the material toward the surface of the carrier to be coated, thus permitting the field to disperse the entire sand-shower. The method also contemplates the selecting off from the dispersed or electrified shower, as by means of a baffle, any excess sand not desired, and permitting the remainder to drop with the particles in their properly dispersed relation and also individually oriented, i. e., sharpest points up, upon the adhesive surface. By properly arranging the electrostatic field, the method will also maintain a predetermined relation between each particle in the field until it is united with the surface, thus obtaining exposure of the sharpest and most abrasive portion of each particle.

In carrying out the method, a supply of sand may be arranged in a hopper above an adhesively surfaced carrier or backing. The hopper may, if desired, be provided with an adjustable gate and feed roll for controlling to a certain extent the showering of the sand upon the adhesive surface to be coated, although the sand may be dropped toward the carrier in surplus quantities. The electrostatic field is disposed between the carrier and gate, so that the sand must travel through or adjacent the field before it reaches the carrier.

The sand particles are each influenced by the electrical charge, which serves to fan or spread out and disperse the shower, maintaining the particles in substantially uniformly spaced relation until they reach the carrier. It will be found that the voltage or power of the field may be regulated to control the extent to which the particles are fanned out or dispersed, and, of course, a factor in this control will be the character of the coating desired. If a closed coating devoid of ridges or bunchiness is desired, the field will be of a character which will simply provide the uniform distribution necessary to prevent these defects. If an open coating is required, the field will be controlled so as to disperse the particles relatively to one another to a greater extent. If the sand is showered in surplus quantities, a baffle or diverting plate may be suitably arranged to divert from the normal path of the shower any portion thereof which it is desired to exclude from the carrier. The position of the baffle will, of course, vary depending upon the character of the coating desired, and the amount of sand being showered toward the carrier surface.

The particles not led off from the shower continue on to the carrier and fall upon its adhesive surface. Due to the dispersing action of the electrostatic field, the particles are deposited upon this surface in substantially uniformly spaced relation, thus providing an ideal open coating. When applied to an abrasive medium

such as sand, the electrostatic field has been found to be extremely efficient, and even though the controlling gate is opened quite wide to overcome the packing tendency of fine sands, and to provide a flow in excess of that required to use a coating, the use of the field will properly disperse the entire shower from which may be laid off such excess portions as are not to be permitted to fall upon the adhesive surface. The use of such an excess flow eliminates the necessity for maintaining the gate and feed roll accurately ground or adjusted, and moreover, the irregularities of sand flow due to surface imperfections on the gate or roll have been found to be relatively small in relation to the large amount of sand flowing.

As will be understood, the deposition of the particles upon the carrier uninfluenced by any force which tends to oppose the effect of the electrostatic field, except, of course, the weight of the particles themselves, permits the field to effect desired control of position and the particles are, as a result, arranged upon the carrier under the influence of the field substantially unaffected by any other force.

Furthermore, it has been found that the resultant abrasive surface is much sharper than a surface produced by simply dropping the material upon the carrier, even though attempts may be made to control the arrangement of the same by other media than electrical means.

In obtaining the proper orientation of each individual particle with its sharpest portion exposed, it is thought that the field causes substantially each particle to align itself so that its longest axis is virtually parallel to the lines of force of the field. The rate of discharge of an electrostatic charge is dependent upon the surface characteristics of the charged body, and the larger the radius of curvature, the slower the rate of discharge, and the sharper the point, the faster the rate of discharge. It is believed that this relation of the rate of discharge of the surface characteristic of the charged body, e. g., sand grain with a pointed abrasive portion, discharge of the surface characteristic of the charged body, e. g., sand grain with a pointed abrasive portion, causes the sharpest points of the grains to orient themselves so that their major axes are parallel to the lines of force of the field, with the result that the particles are deposited upon the surface with their sharpest points directed away from the carrier and with the major axes of the particles perpendicular to the carrier. Consequently, the points are made to project outwardly, and the resultant coating is very much sharper than a coating made without the use of an electrical force for orientating or arranging each individual particle. Obviously, of course, such an arrangement or orientation of the particles is useful in either a closed or open coating, since it (1) increases the sharpness of the coating and enables faster and easier cutting, (2) minimizes heating and loading, and (3) increases the cutting life or capacity of the abrasive surface.

Moreover, it will be clear that the use of the electrostatic field in the formation of a closed coating prevents bumping or bunching of the sand by distributing the same over the entire area or surface to be coated. It blends out the irregularities which would otherwise develop in the stream due to lack of uniformity in the feed gate and to other factors which modify the effect of gravity, or other means which may be used to direct the stream to the carrier.

It will be understood, of course, that the electrostatic field can be used as a dispersing means with any type of particles whether abrasive or non-abrasive, to insure a uniform distribution, and irrespective of the nature of the substance or carrier upon which they are being deposited.

In the manufacture of sand paper, the electrostatic field is particularly useful. Although, in producing any particular grade of paper the particles are of approximately equal size and weight, it has, for many years, been the practice to use particles known as (a) control, (b) undergrade, and (c) overgrade; the control particles predominate. It has been found that the electrostatic field utilized in the manner herein described tends to stratify the particles and cause to locate on the top surface the larger particles, that is, the particles having larger areas of cutting surface.

It will be understood, therefore, that the control or change of position of the various particles effected by the field has three characteristics: First, the particles are oriented or turned by the lines of force so that the sharper surfaces of the abrasive coating are exposed. Second, the various particles are stratified so that the larger or more effective particles are on the surface. Third, the particles are dispersed to produce a more uniform coating, due to the fact that they are mutually repellent.

The dispersion of the particles is caused by the fact that, as they enter the field, they acquire a charge of the same polarity of that of one of the poles forming the field, and since all of the particles have been graded to approximately the same size, although some are undergrade, some are overgrade and others are control particles, they all acquire a charge of approximately equal intensity and of the same polarity. Hence, all of the particles in any shower, as they pass through the field on their path to the other pole are mutually repellent with a substantially equal repelling force and thus arrange themselves so that they are substantially equidistant in all directions. This repelling action is effected not only as the particles pass through the field but on the carrier.

It is preferred that the electrical field be arranged at the point of deposition of the particles, so that this control of position is exercised at the point of deposition and at the time the particles strike the carrier. As a consequence, the positions of the particles will be controlled before the adhesive has set and will be effected on the carrier as well as in the path of the particles to the carrier.

In practicing the method, various forms of apparatus may be employed, and in the accompanying drawings showing a preferred form:

Figure 1 is a vertical sectional view on substantially the line 1—1, of Figure 2.

Figure 2 is a vertical sectional view on the line 2—2 of Figure 1.

Figure 3 is a horizontal sectional view on the line 3—3 of Figure 1, with the feed roll shown in elevation, and partly broken away.

Figure 4 is a fragmentary sectional view on the line 4—4 of Figure 1.

Figure 5 is a cross sectional view of a modified form of discharge electrode.

Figure 6 is an elevational view of a modified form of discharge or high potential electrode having its ends formed to eliminate "end effect", and

Figure 7 is a top plan view of another form of discharge electrode.

Referring to the accompanying drawings for a more detailed description, 10 indicates the carrier or paper sheet which may be fed in the direction of the arrows 11 by suitable means (not shown) over a roll 12 having end bearings in brackets 12' on the frame 13'. As will be understood, the paper has an adhesively coated top surface exposed to receive sand or other abrasive material dropped from a hopper 13, the lower end of which is partly closed by a feed roll 14. A wall of the hopper terminates at 15, a short distance above the feed roll to provide a discharge opening for the sand, which may be entirely closed by means of a shut-off gate 16 operable by means of a pair of rack bars 17 engaged by gears 18 upon a rock shaft 19, the latter carrying an operating lever 20 and being mounted in bearings 21 upon the wall of the hopper. The gate 16 is provided for the purpose of entirely shutting off the supply of sand when desired, and a second regulating gate 22 for adjusting the size of the opening between the lower end of the gate 16 and the periphery of the sand roll is adjustably mounted in brackets 23 by means of adjusting rods 24 secured to an outwardly extending rib 25 upon the gate, and extending through openings in the bracket. Clamping nuts 26 on opposite sides of the bracket webs through which the bolts 24 extend serve to secure the gate in any set position. As will be observed from Figure 4, the shut-off gate 16 is arranged between the regulating gate and the hopper wall, and it fits closely in a slideway formed by strips 27 secured to the hopper by bolts 28. The regulating gate 22 is provided on its rear surface with ribs 29 which abut the face of the shut-off gate and assist in providing a guideway for the same.

As the regulating gate is adjusted by means of the adjusting bolts 24, it is adapted to slide in grooves 30 (Fig. 4) formed by the strips 27 secured to the hopper.

When sand or other finely divided abrasive material is arranged within the hopper, operation of the feed roll in the direction of the arrow 31 (Fig. 1) after the shut-off gate has been opened and the regulating gate has been suitably adjusted, will cause the sand to drop downwardly in a shower toward the exposed adhesively coated surface of the carrier 10. Thus, by the use of the feeding means and gravity, the abrasive particles are introduced into an electrical field which is established in the manner hereinafter described.

The amount of sand discharged between the periphery of the sand roll and the end 22' of the adjusting gate 22, will, of course, depend upon the adjustment of the gate.

An electrostatic field may be formed by means of a tube 36 connected, as by means of a lead wire 35, to a source of high voltage (not shown). The tube 36 may be supported at its ends by mounts of insulating posts 37 carried by brackets 38 upon the frame 13'. The brackets 38 may be provided with elongated slots 40 receiving bolts 41 with clamping nuts 42, whereby the position of the electrode may be varied as desired. The zero or ground potential side of the field may be provided by means of the paper carrying roll 12 which may be formed of suitable material and connected with the ground, as by means of a lead 43. The field formed by the tube 36 and roll 12 may be varied in intensity and extent, as desired. For instance, it is possible to make a field of higher unit intensity by reducing the diameter of the tube 36, or a broader field and one of lower unit intensity, by increasing the diameter of the electrode 36. Moreover, the proximity of ground or zero potential affects the field, and if desired, a multiplicity of tubes 36 may be employed.

In order to avoid "end effect", the ends of the tube may be rounded, as illustrated in Fig. 6, wherein 'the tube 36' is provided with rounded ends or heads 44 which are seated in sockets 45 provided in the insulating post 46.

Furthermore, it has been found at times that by moving the tube 36, as by rotation, will have a pronounced effect upon the character of the field, and that instead of the tube 36, a solid rod may be employed if desired. In some instances, instead of a hollow tube, a wire brush, or a series of wires, such as piano wires, have been found to provide efficient electrodes and to alter the character of the electrostatic field to meet specialized conditions in the application of abrasive material.

Another modified form of electrode is shown in Figure 7, wherein the electrode is provided at one end with a substantially horizontally extending rigid strip 50 of metal, such as copper wire or brass, and at the other end, the lead 35' is directed substantially horizontally, and is exposed for the purpose of providing in effect angularly bent ends of the electrode tube 36'', which may be supported upon the insulating posts 37'. The strip and exposed lead wire being directed toward the sand shower at an angle of about 45° to the tube, serve to decrease "end effect" and to fan out the edge of the sand shower, which, as will be understood, in dropping upon the abrasive material passes through the field. The field may thus be regulated in a manner to modify the dispersing or spacing of the abrasive particles. The variation of the field intensity also necessarily or inherently varies the pull of the particles into the adhesive to a greater or less extent and thus modifies their depth of penetration in the adhesive coat. As the sand enters the electrostatic field, the particles are dispersed, and in such dispersed relation are deposited upon the adhesive surface of the carrier 10. It will be understood, of course, that when the particles enter the field, they receive a charge and the field has the effect of causing a movement of the particles from one pole toward the other. When the poles and carrier with its adhesive surface are arranged as illustrated with the carrier between the poles, the adhesive surface interrupts this flow from the pole 36 toward the pole formed by the roll 12, so that the adhesive surface is contacted by the charged particles in the course of this flow. The effect of the field is to fan out or spread the shower of sand, as illustrated in Figure 1, and ordinarily it has been found that it is preferable to position the regulating gate 22, so that an excess or surplus amount of sand is discharged from the hopper. In order to divert from the normal path of flow such quantity as should not fall upon the carrier, a baffle or diverting plate 51 is positioned with its surface inclined upwardly toward the feed roll, and with one edge 52 entering the shower of sand. This baffle serves to direct a portion of the shower over its surface downwardly into a hopper 53, from which the sand may be removed as desired.

In order to provide suitable means for varying the position of the baffle, so that the amount of sand selected off from the shower may be accurately regulated, the baffle is provided with a

pair of upstanding slotted lugs 84, into the slots of which project clamping bolts 85 carried by adjusting arms 86 (Figure 2) which are positioned upon a cross head 87 having end blocks 88 slidably mounted in brackets 89 upon the frame 20. Adjusting screws 90 are threaded in walls 90' of the brackets 89 and have heads 91 swivelled in the bosses 92. As will be understood, manipulation of the screws 90 will guide the blocks and cross head 87 toward and from the sand shower, and thus move the baffle horizontally. The angular portion of the baffle may be varied at the clamping bolts 85, and as will be observed, the arms 86 are provided with a series of openings 86' so that their effective length may be altered.

In Figure 5 there is shown a modified form of electrode comprising an electrified tube 82, which is arranged within a tube 83 of considerably larger diameter and in electrical contact with the electrified tube, by which it is supported. The outer tube considerably enlarges the effective diameter of the electrode, and as will be understood, broadens the field produced. The rod 82 may be connected to a source of high voltage in any suitable manner (not shown).

In operating the apparatus, the position of the baffle 81 will, of course, determine the portion of sand showered from the hopper which will be permitted to fall upon the adhesive surface. As has been explained, instead of bringing the end 22' of the gate close to the feed roll, even with extremely fine sands, in order to determine the exact amount of sand necessary to make the coating desired, the gate is preferably opened sufficiently wide to overcome the packing tendencies of said sands and to obtain a uniform flow, which is in excess of that required to produce a satisfactory coating. The comparatively heavy flow of sand eliminates the necessity for keeping the gate and feed roll perfectly ground, because the irregularities in the sand flow due to surface imperfections on the gate or roll, are very small in proportion to the large amount of sand flowing. As the sand stream leaves the gate, it passes within the influence of the electrostatic field, and immediately causes a dispersion of the particles or a fanning out or widening of the stream or shower. As has been explained, this dispersion can be varied by changing the characteristics of the field by any of the means described. Moreover, varying the voltage controlling the field will control the dispersing action of the same. The adjustment of the baffle 81 will regulate the amount of the shower, which is diverted from the path toward the surface to be coated, and in ordinary practice, it will be found that the control of the amount of grain applied and the character of the coating may be effectively controlled by varying the voltage without making adjustments in the apparatus.

Since the tube 26 is sufficiently long (Fig. 2) to extend beyond the edges of the paper, the sand will be uniformly applied throughout the entire width of the same, and by properly regulating the speed of travel of the paper, the sand may be continuously applied as the paper travels over the roll 12 to a takeup roll (not shown).

As illustrated in Figure 1, the abrasively coated adhesive surface is conducted from the electrical field over the rolls 12, which engage the undersurface or non-coated surface of the carrier. In other words, the material is completed to provide a finished material having the abrasive particles in their oriented spaced relation determined by the electrical field and the finished product has the characteristics hereinbefore described.

As will be understood, the electrical field is established altogether independently of the carrier, and neither the carrier nor the coating is relied upon to establish the field. As a result, the method is applicable to the manufacture of abrasives with substantially all kinds of adhesive coatings, and the creation of the field is not dependent upon the carrier coating or the movement of the carrier. Moreover, it is possible to localize the field at the point of deposition and to maintain the same of the desired character and strength, in accordance with the regulation of the field, independently of the carrier movement or its coating characteristics.

By the expression "mechanically directing" or "mechanically propelling" the abrasive particles, is meant the subjection of the particles to a force independent of the electrical field and which directs or propels the particles toward the adhesive surface of the carrier.

By the expression "adhesively retaining" as used in the claims with reference to the retention of the particles upon the carrier, is meant the use of means other than electricity for retaining by adhesive action the coating material upon the carrier. By "abrasive" is meant any abrasive or coating material in fragmentary form; by "carrier" is meant any desired material or support on which the fragmentary or divided material may be superimposed or deposited; by "controlled" or "regulated" as applied to the supply or feed of finely divided material to the carrier is meant simply that the material is supplied in such a way as to be responsive to the action of the electrical field for the result desired, whether dispersion or orientation or both.

Obviously, numerous modifications may be made in the structure illustrated and described without departing from the invention, the essence of which is more definitely set forth in the following claims.

I claim:—

1. That improvement in the art of coating a carrier with finely divided abrasive material which consists in gravitationally supplying abrasive particles to the carrier, controlling the positions of the particles upon the carrier by the action of an electrical field substantially at their point of deposition upon the carrier, and adhesively retaining the particles upon the carrier with the positions of the particles arranged by the electrical field.

2. In the art of coating, the improved method which consists in disposing a carrier beneath a source of finely divided abrasive material, dropping the material in controlled amount upon the carrier and subjecting the material as it travels to the carrier to the action of an electrical field so disposed as to orient the individual particles and adhesively retaining the material upon the carrier.

3. In the art of coating, the improvement which consists in supplying by gravity to a permanent carrier regulated amounts of finely divided solid material of a character adapted to be dispersed by electrical action, providing adhesive for retaining the particles on the carrier and dispersing the material in its gravitational path to the carrier by the action of an electrical field, whereby the particles are deposited thereon in dispersed relation.

4. In the art of sand coating a carrier, the im-

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provement which consists in supplying by gravity to the carrier regulated amounts of sand, providing an adhesive for retaining the sand particles on the carrier and dispersing the sand particles by the action of an electrical field as they are applied to the carrier.

5. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive depositing by gravity finely divided abrasive material upon said surface and dispersing the particles by the action of an electrical field as they are being deposited upon the surface.

6. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, depositing sand by gravity upon said surface and dispersing the particles by the action of an electrical field as they are deposited upon the surface.

7. In the manufacture of abrasives, the improved method which consists in depositing abrasive particles by gravity upon a carrier surface, providing an adhesive material for retaining the particles on the carrier, and dispersing the particles by the action of an electrical field as they are applied to the carrier.

8. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, depositing by gravity finely divided non-magnetic abrasive material upon said surface from a point thereabove and dispersing the particles upon the surface by the action of an electrical field.

9. An apparatus for the manufacture of coated carriers comprising means for vertically directing a controlled feed of finely divided solid material adapted to be dispersed by an electrical field, means for supporting in the path of said feed an adhesively surfaced carrier to be coated, and a pair of stationary electrodes for producing an electrical field to disperse the individual particles of finely divided material upon said adhesive surface as the material is supplied thereto.

10. An apparatus for the manufacture of coated carriers comprising means for mechanically projecting a controlled feed of finely divided solid material adapted to be dispersed by an electrical field, means for supporting and causing to travel in the path of said material an adhesively surfaced carrier to be coated, and a pair of stationary electrodes for producing an electrical field to disperse the individual particles of finely divided material upon said adhesive surface as the material is supplied thereto.

11. Apparatus for the manufacture of abrasives comprising means for supporting and feeding a carrier provided with a surface coated with an adhesive material for the reception of abrasive particles, means for mechanically projecting toward said adhesive finely divided abrasive material in controlled amount, and stationary electrodes for producing an electrical field adjacent the path of said finely divided material whereby to disperse the particles as they travel toward the adhesive surface, thereby to cause the same to be deposited on said surface in dispersed relation, and means for continuously conducting the abrasively coated carrier away from said field to produce a material having the particles fixed thereon in their positions as determined by the electrical field.

12. Apparatus for the manufacture of abrasively coated carriers comprising means for supporting a carrier having a surface coated with an adhesive material adapted to receive and retain abrasive particles, means above said carrier for supplying by gravity to said adhesive finely divided abrasive material, and means for producing an electrical field adjacent the gravitational path of said material, whereby to disperse the particles as they travel toward the adhesive surface and cause the same to be deposited thereon in dispersed relation.

13. Apparatus for the manufacture of abrasives comprising means for supporting a carrier having a surface coated with an adhesive adapted to receive and retain abrasive particles, means for mechanically directing abrasive particles toward said adhesive surface in controlled amount, and a pair of stationary electrodes for creating adjacent the path of the particles an electrical field adapted to disperse the particles as they travel toward the adhesive surface, whereby to cause the particles to be dispersed on said surface in dispersed relation.

14. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, gravitationally directing abrasive particles toward said adhesively coated surface, and controlling the position of the particles relative to one another on the carrier by an electrical field.

15. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, directing by gravity abrasive particles toward said adhesively coated surface, and controlling the position of the particles relative to one another in their path to the carrier and on the carrier by an electrical field.

16. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, directing abrasive particles toward said carrier by the action of gravity, and controlling the position of the particles relative to one another on the carrier by an electrical field.

17. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface coated with an adhesive, directing abrasive particles toward said carrier by the action of gravity, and controlling the position of the particles relative to one another in their path to the carrier and on the carrier by an electrical field.

18. In the manufacture of abrasives, the improved method which consists in providing a carrier, directing abrasive particles toward said carrier, controlling the position of the particles relative to one another in their path to the carrier by an electrical field and varying the relative positions of the particles in said path by regulating the electrical field.

19. Apparatus for the manufacture of abrasives, comprising means for supporting a carrier having a surface coated with an adhesive adapted to receive and retain abrasive particles, means above said carrier for supplying abrasive particles and directing the same by gravity toward said surface, and an electrical field disposed in the path of said particles so as to control the arrangement of the same relative to one another at the time they are deposited upon the carrier.

20. Apparatus for the manufacture of abrasives, comprising means for supporting a carrier having a surface coated with an adhesive adapted to receive and retain abrasive particles, means above said carrier for supplying abrasive particles

and directing the same by gravity toward said surface, and an electrical field disposed in the path of said particles so as to control the arrangement of the same relative to one another at the time they are deposited upon the carrier, said means being variable whereby to vary the distribution of the particles relative to one another.

21. Apparatus for the manufacture of abrasives, comprising means for supporting a carrier having a surface coated with an adhesive adapted to receive and retain abrasive particles, means for supplying abrasive particles and directing the same toward said surface, an electrical field disposed in the path of said particles so as to control the arrangement of the same relative to one another at the time they are deposited upon the carrier, and means positioned to deflect from said path and away from the carrier particles directed thereto by said first-mentioned means.

22. Apparatus for the manufacture of abrasives, comprising means for supporting a carrier having a surface coated with an adhesive adapted to receive and retain abrasive particles, means for supplying a stream of abrasive particles and directing the same toward said surface, an electrical field disposed in the path of said particles so as to control the arrangement of the same relative to one another at the time they are deposited upon the carrier, and means positioned to deflect from said path and away from the carrier particles directed thereto by said first-mentioned means, said deflecting means being adjustable in position relative to said path whereby to vary the amount of particle stream deflected thereby.

23. Apparatus for the manufacture of abrasives comprising means for conducting an adhesively coated carrier along a predetermined path, a pair of stationary electrodes adjacent said path for creating an electrical field adapted to control the positions of abrasive particles on said carrier, said electrodes serving to create the field independently of the carrier, and means for supplying under the action of said field to said carrier finely divided abrasive particles.

24. Apparatus for the manufacture of abrasives comprising means for conducting an adhesively coated carrier along a predetermined path, a pair of stationary electrodes adjacent said path for creating an electrical field adapted to control the positions of the particles on said carrier, said electrodes serving to create the field independently of the carrier, and means for supplying by gravity to said carrier finely divided abrasive particles.

25. Apparatus for the manufacture of abrasives comprising means for conducting an adhesively coated carrier along a predetermined path, a pair of stationary electrodes adjacent said path for creating an electrical field adapted to control the positions of the particles on said carrier, said electrodes serving to create the field independently of the carrier, and means for supplying to said carrier finely divided abrasive particles, said supplying means serving to deposit the particles on the carrier adjacent the electrical field whereby to effect said control of the positions of the particles by the field substantially at the point of deposition of the particles.

26. Apparatus for making abrasive paper comprising means for conveying a paper backing having an adhesive surface in a substantially horizontal direction, means for supplying abrasive particles and depositing the same upon the backing in a substantially vertical direction, and means for producing an electrical field through which the particles pass on their way to the backing, the lines of force intersecting the path of the particles as it approaches the adhesive surface.

27. In the manufacture of abrasives, the improved method which consists in conducting along a substantially horizontal path an adhesively coated carrier, producing independently of the carrier an electrical field adjacent said path, mechanically directing in a substantially vertical path finely divided abrasive particles to said carrier and depositing the particles on the carrier within the field, and utilizing the electrical field to orient and disperse the particles on the carrier.

28. In the manufacture of abrasives, the improved method which consists in providing a moving carrier having an adhesively coated surface, mechanically projecting abrasive particles toward said surface, controlling the position of the particles relative to one another as they pass to the carrier by an electrical field, and varying the relative positions of the particles in said path and on the carrier by regulating the field.

29. In the manufacture of abrasives, the method which consists in conducting along a path an adhesively coated carrier, creating adjacent said path independently of the carrier and its coating an electrical field, supplying by gravity finely divided abrasive particles to said carrier and utilizing the electrical field to control the positions of the particles on the carrier.

30. In the manufacture of abrasives, the method which consists in conducting along a substantially horizontal path an adhesively coated carrier, creating adjacent said path independently of the carrier and its coating an electrical field, projecting in a substantially vertical path finely divided abrasive particles through the field to said carrier and utilizing the electrical field to control the positions of the particles on the carrier.

31. In the manufacture of abrasives, the improved method of making an "open-coat" abrasive article which consists in establishing an electrical field, supplying finely divided abrasive particles to the electrical field, orienting and dispersing the particles in spaced relation by the electrical field, positioning the dispersed and oriented particles on an adhesively coated carrier, and conducting the carrier away from the field and uniting the particles to the carrier to produce a material having the particles in oriented and spaced positions on said carrier as determined by the electrical field.

32. In the manufacture of abrasives, the improved method of making an "open-coat" abrasive article which consists in conducting an adhesively coated carrier along a predetermined path, establishing an electrical field independently of said carrier, initiating movement of finely divided abrasive particles toward the carrier utilizing the electrical field to disperse in spaced relation the particles on the carrier and conducting the carrier away from the field and uniting the particles to the carrier to produce a material having the particles fixed in spaced relation determined by the electrical field.

33. In the manufacture of abrasives, the improved method which consists in conducting an adhesively coated carrier along a substantially horizontal path, establishing an electrical field independently of the carrier, the lines of force of the field intersecting the surface of the carrier, introducing finely divided abrasive particles into

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said field, utilizing the electrical field to disperse in spaced relation the particles on the carrier and conducting the carrier away from the field to produce a material having the particles fixed in spaced relation determined by the electrical field.

34. In the manufacture of abrasives, the improved method which consists in conducting an adhesively coated carrier along a substantially horizontal path, establishing an electrical field independently of the carrier, the lines of force of the field intersecting the surface of the carrier, introducing finely divided abrasive particles into said field, utilizing the electrical field to disperse and orient in spaced relation the particles on the carrier and conducting the carrier away from the field to produce a material having the particles fixed in their oriented spaced relation determined by the electrical field.

35. In the manufacture of abrasives, the improved method which consists in conducting an adhesively coated carrier along a predetermined path, establishing an electrical field independently of said carrier, bringing finely divided abrasive particles into said field, utilizing the electrical field to disperse the particles in spaced relation on the carrier and conducting the carrier away from the field to produce a material having the particles fixed in their spaced relation determined by the electrical field.

36. In the manufacture of abrasives, the improved method which consists in conducting along a substantially horizontal path an adhesively coated carrier, establishing an electrical field independently of the carrier, the lines of force of the field intersecting the surface of the carrier, introducing finely divided abrasive particles into said field and utilizing the electrical field to move the particles along the lines of force of the field into the adhesive surface of the carrier and conducting the carrier away from the field to provide a finished material having the particles fixed in their positions as determined by the electrical field.

37. Apparatus for making an abrasive material, comprising electrodes of opposite polarity for establishing an electrical field, means for conveying a backing material having an adhesive surface through said field established by said electrodes independently of the backing material, and means for supplying finely divided abrasive material to said field, the field being arranged to disperse and orient the particles on the adhesive surface of the carrier as it moves therethrough.

38. Apparatus for making abrasive material, comprising electrodes of opposite polarity for establishing an electrical field, means for conveying a backing material having an adhesive surface through said field established by the electrodes independently of the backing material, and means for causing movement of finely divided abrasive particles into said field, said field being arranged to disperse the particles on the adhesive surface of the carrier.

39. In the manufacture of abrasives, the improved method which consists in moving an adhesively coated carrier along a predetermined path, establishing an electrical field between poles of opposite polarity and independently of the carrier, introducing finely divided abrasive particles into said field to receive a charge, and passing the carrier through said established field between said poles with the adhesive surface arranged to be engaged by the charged particles and to interrupt their movement from one pole toward the other.

40. In the manufacture of abrasives, the improved method which consists in moving an adhesively coated carrier along a predetermined path, establishing an electrical field between poles of opposite polarity and independently of the carrier, introducing finely divided abrasive particles into said field to receive a charge, passing the carrier through said established field between said poles with the adhesive surface arranged to be engaged by the charged particles and to interrupt their movement from one pole toward the other and conducting the carrier from the field to produce a finished material having the particles arranged as determined by the field.

41. In the art of coating sheet material, the improved method which consists in moving an adhesively coated sheet-carrier along a predetermined path, establishing by electrode means independent of the carrier an electrical field with its lines of force crossing said path and introducing into said field fragmentary material of a character adapted to be arranged by an electrical field to receive a charge and to be moved by said field against the adhesive surface of the carrier while passing the carrier through said field with the adhesive surface arranged to be engaged by the charged particles and to interrupt their movement by the field.

42. In the art of coating sheet material, the improved method which consists in moving an adhesively coated sheet-carrier along a predetermined path, establishing by electrode means independent of the carrier an electrical field with its lines of force crossing said path and introducing into said field a controlled feed of fragmentary material of a character adapted to be arranged by an electrical field to receive a charge and to be moved by said field against the adhesive surface of the carrier while passing the carrier through said field along said path with the adhesive surface arranged to be engaged by the charged particles and to interrupt their movement by the field.

43. Apparatus for the manufacture of coated sheet material comprising means for conducting an adhesively coated sheet-carrier along a predetermined path, electrode means adjacent said path and independent of a carrier conducted by said first mentioned means for creating an electrical field having its lines of force crossing said path and adapted to arrange fragmentary material of a character adapted to be arranged by an electrical field on the adhesive surface of a carrier conducted along said path by said conducting means, and means for supplying a controlled feed of fragmentary material to said field during the operation of said conducting means.

44. Apparatus for the manufacture of coated sheet material comprising means for conducting an adhesively coated carrier along a predetermined path, stationary electrode means adjacent said path for creating an electrical field having the lines of force crossing said path and adapted to project fragmentary material of a character adapted to be arranged by an electrical field against the adhesive surface of a carrier conducted along said path by said first mentioned means, said second mentioned means serving to create the field independently of a carrier conducted by said first mentioned means, and means for supplying fragmentary material to said field during the operation of said conducting means.

45. Apparatus for the manufacture of coated

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sheet material comprising means for continuously conducting an adhesively coated carrier along a predetermined path, stationary electrode means adjacent said path for creating an electrical field having the lines of force crossing said path and adapted to project fragmentary material of a character adapted to be arranged by an electrical field against the adhesive surface of a carrier conducted along said path by said first mentioned means, said second mentioned means serving to create the field independently of a carrier conducted by said first mentioned means, and means for continuously supplying a controlled feed of fragmentary material to said field during the operation of said conducting means.

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Jan. 7, 1936. O. S. BUCKNER 2,027,087

ABRASIVE SHEET AND PROCESS OF MAKING THE SAME

Filed Oct. 3, 1929

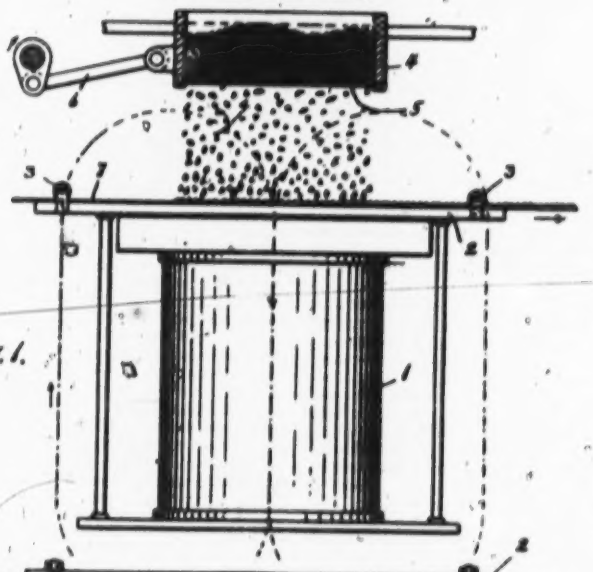

Fig. 1.

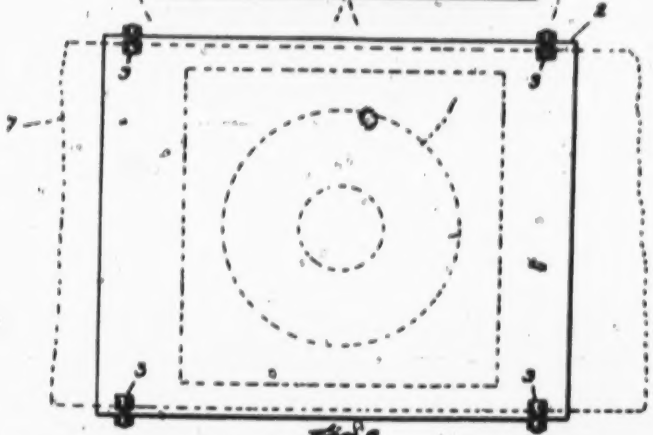

Fig. 2.

Fig. 3.

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UNITED STATES PATENT OFFICE

2,027,067

ABRASIVE SHEET AND PROCESS OF MAKING THE SAME

Orville S. Buckner, Westboro, Mass., assignor to Behr-Manning Corporation, Troy, N. Y., a corporation of Massachusetts

Application October 3, 1933, Serial No. 218,033

8 Claims. (Cl. 91—68)

This invention relates to a modified form of the invention disclosed in my issued Patent 1,830,788, dated October 17, 1933, which relates to abrasive or attrition tools and methods of making the same, and in the construction of which the elongated grains of abrasive material are electrically positioned, so that they are bonded in approximately perpendicular relation to the working face of the tool.

The present invention relates, more specifically to an application of the generic invention to the production of abrasive or attrition sheets and has for its object the production of a sheet of this character which has the essential characteristics of the abrasive tools previously disclosed in said application and to a method of making the same which will be commercially successful.

I accomplish these objects in the manner hereinafter described and illustrated in the accompanying drawing in which:

Fig. 1 is a side elevation of the essential features of an apparatus which I preferably employ in performing the process of making attrition sheets.

Fig. 2 is a plan view thereof.

Fig. 3 is a sectional view of the finished product.

In carrying out the method of the present invention, in order to make the abrasive material responsive to a magnetic field the abrasive grains are coated with a moist adhesive, then are mixed with finely pulverized iron or steel, and then the adhesive is permitted to dry, so that the grains become coated with a magnetic substance. As some of the grains are likely to adhere to each other, this adhesion must then be broken, and this may be accomplished in various ways, as by working the same through a wire screen of suitable mesh.

As thus prepared, the grains are applied to sheets of suitable material in the following manner; the apparatus which is preferably employed comprising an electromagnet 1 of straight cylindrical form having the faces of its ends, which form the poles, disposed in planes perpendicular to the central axis of the magnet, the latter being disposed perpendicularly so that said faces will be horizontal. A table 2 of thin brass, or similar non-magnetic substance is disposed on the top end of the magnet and is provided with a series of suitably arranged guide-rolls 3-3 at its edges beneath which the sheets to be coated are passed. A receptacle 4 having a wire mesh bottom 5 is mounted horizontally directly over the magnet, suitable agitating means 6 being provided for moving the receptacle horizontally.

The paper, cloth, or other form of sheet material 7 is coated with a suitable adherent as glue and is then fed over the table 2 beneath rolls 3, to hold it flat, while resting on its surface. The abrasive grains which have previously been coated with the finely divided magnetic dust are placed in the receptacle 4, which is then agitated in any suitable manner as by the reciprocating means indicated, so that the grains will be showered onto the adhesively coated sheet as it is fed over the pole of the magnet. The lines of force of the magnet passing from one pole to the other have principally an approximately vertical direction close to the surface of the sheet and will cause the magnetically coated grains, most of which will be somewhat elongated, or will have one dimension substantially greater than the dimension at right angles thereto, to be polarized as they fall, so that, assuming the pole at the top of the magnet is positive, the negatively magnetized ends of the grains will be attracted and the positive ends repulsed, and they will be turned while falling into approximately perpendicular relation to the face of the sheet, with the result that the ends of the elongated grains will penetrate the adhesive coating and will stand upright thereon, as indicated in Figs. 1 and 3. As hereinafter explained, it is an object of the invention to provide a final product in which the grains are substantially all arranged with their major axes substantially perpendicular to the carrier sheet and the further operations are performed to provide a material having these characteristics.

The adhesive will then be permitted to set while still held horizontally and, after this has occurred, the surplus grains which did not penetrate or touch the adhesive will be shaken off.

The material after these operations have been performed does not have the arrangement of the particles effected by the magnetic field appreciably disturbed. In other words, the resulting abrasive sheet will have practically all the elongated abrasive grains thereon oriented to stand perpendicularly, so that the shredding efficiency of the sheet will be much greater than if they lie flatwise of the sheet, on account of the superior cutting qualities of the ends of the abrasive grains, as compared with the sides thereof. The coating of abrasive grains, which is applied to the sheet will also be of greater thickness than it would be if the grains were not positioned on the sheet in perpendicular relation thereto.

I claim:

1. The method of making attrition sheets

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which consists in placing a sheet having an adhesive surface in a magnetic field, so that the lines of force pass approximately perpendicularly therethrough and showering magnetically coated elongated grains of abrasive material onto said surface.

2. The method of making attrition sheets which consists in providing a sheet of suitable material with an adhesive surface, showering granular abrasive material containing a substantial portion of elongated grains onto said surface and simultaneously magnetically positioning said elongated grains, as they fall, in approximately perpendicular relation to said surface, so that the end portions of said grains may penetrate said surface and become bonded thereto in approximately perpendicular relation thereto.

3. The method of making attrition sheets which consists in covering one surface of a sheet with a suitable adhesive material, passing the sheet while held horizontally with its adhesive side uppermost through the field of a magnet so that the lines of force thereof pass mainly approximately perpendicularly through the sheet and showering magnetically coated elongated abrasive grains through the field of the magnet onto said surface.

4. The process of making abrasive material which comprises providing a magnetic field, feeding a carrier having a surface coated with adhesive through said field with the lines of force of the field at an angle to the adhesively coated surface of the carrier, causing abrasive particles of a character responsive to magnetic action to be deposited on the carrier, utilizing the field to arrange the particles on the adhesive surface with their major axes substantially perpendicular to the adhesive surface, and conducting the abrasively coated carrier away from the field as the particles are deposited thereon.

5. The process of making abrasive material which comprises providing an electromagnetic field, feeding a carrier having a surface coated with adhesive through said field with the lines of force of the field at an angle to the adhesively coated surface of the carrier, causing abrasive particles of a character responsive to electromagnetic action to be deposited on the carrier, utilizing the field to arrange the particles on the adhesive surface with their major axes substantially perpendicular to the adhesive surface, and conducting the abrasively coated carrier away from the field as the particles are deposited thereon.

6. The process of making abrasive material which comprises providing a magnetic field, feeding a carrier having a surface coated with adhesive through said field with the lines of force of the field at an angle to the adhesively coated surface of the carrier, causing abrasive particles of a character responsive to magnetic action to be deposited on the carrier, utilizing the field to arrange the particles on the adhesive surface with their major axes substantially perpendicular to the adhesive surface, conducting the abrasively coated carrier away from the field as the particles are deposited thereon, and performing the finishing operation to produce a material having the particles with their major axes substantially perpendicular to the adhesive surface.

7. The process of making abrasive material which comprises providing an electromagnetic field, feeding a carrier having a surface coated with adhesive through said field with the lines of force of the field at an angle to the adhesively coated surface of the carrier, causing abrasive particles of a character responsive to electromagnetic action to be deposited on the carrier, utilizing the field to arrange the particles on the adhesive surface with their major axes substantially perpendicular to the adhesive surface, conducting the abrasively coated carrier away from the field as the particles are deposited thereon, and performing the finishing operation to produce a material having the particles with their major axes substantially perpendicular to the adhesive surface.

8. The process of making abrasive material which comprises providing a magnetic field, feeding a carrier having a surface coated with adhesive through said field with the lines of force of the field at an angle to the adhesively coated surface of the carrier, causing abrasive particles of a character responsive to magnetic action to be deposited on the carrier, utilizing the field to arrange the particles on the adhesive surface with their major axes substantially perpendicular to the adhesive surface, conducting the abrasively coated carrier away from the field as the particles are deposited thereon, and permitting the adhesive to set while maintaining the carrier substantially horizontal.

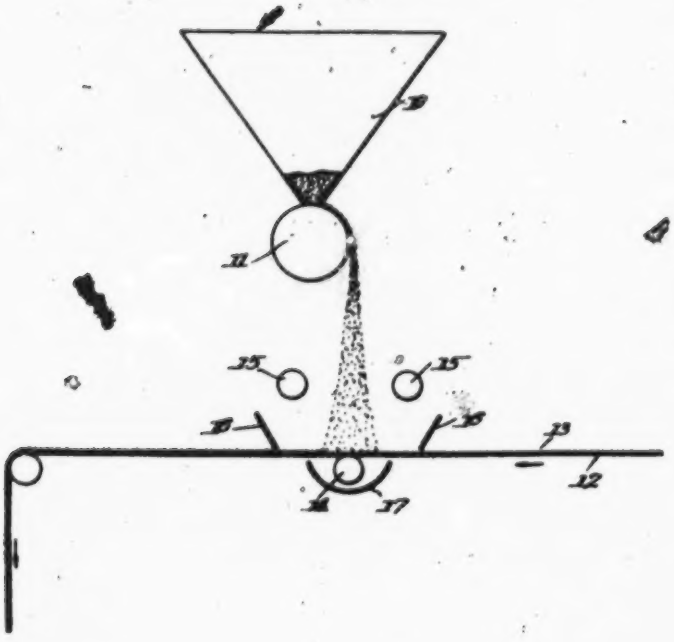
CHELLO S. BUCKNER.

[fol. 551]

Jan. 7, 1936. E. C. SCHACHT 2,027,308

MANUFACTURE OF ABRASIVE ARTICLES

Original Filed Nov. 20, 1931



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[fol. 552]

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2,027,308

UNITED STATES PATENT OFFICE

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MANUFACTURE OF ABRASIVE ARTICLES

Elmer C. Schmidt, Troy, N. Y., assignor, by mesne assignments, to Behr-Manning Corporation, a corporation of Massachusetts

Application November 20, 1931, Serial No. 576,415
Renewed January 7, 1935

5 Claims. (Cl. 91—38)

My invention relates to the manufacture of abrasive articles and particularly flexible abrasive material such as sand paper wherein the abrasive particles are applied to the adhesive surface of a backing or carrier.

The primary object of the invention is to produce a sand paper having optimum cutting efficiency, and wherein the particles are uniformly dispersed, oriented and stratified upon the surface of the backing.

It is a further object of the invention to control the positions of the particles upon the carrier by means of an electrical field which will enclose the sand column adjacent to and about its point of contact with the carrier.

In accordance with the present invention wherein the positions of the sand particles is very definitely controlled, I am enabled to obtain (a) a uniform dispersion to produce a level sand distribution having the maximum number of cutting points, (b) an orientation of the particles such that the longest axes and sharpest edges produce maximum cutting effect, and (c) a stratification or classification whereby the coarser fractions are positioned in the top plane where they produce maximum abrading effect.

The invention is applicable to the manufacture of both "closed coated" and "open coated" sand paper.

In the drawing, the single figure is a diagrammatic view of the invention.

In carrying out the invention, I employ a hopper 10, in which are disposed the abrasive particles. A feed roller or gate 11 is disposed at the mouth of the hopper, so that the particles may be fed in controlled amounts gravitationally.

The particles will comprise the usual mixture, namely of "under grade", "control grade" and "above grade", in which the "control grade" usually predominates.

A carrier or backing 12 of paper, cloth, or laminated structure of the two is arranged to be continuously moved in a position over suitable supporting rollers 13 to receive the sand particles fed from the hopper. This backing or carrier has its surface coated with a suitable adhesive 14 and travels in the direction indicated by the arrows. Disposed below the carrier 12 is an electrode 14, which will be suitably charged from a source of high potential. The electrode will preferably carry a negative charge and will comprise a bar, cylinder or other desired form of element, preferably of the length to extend across the transverse dimension of the web 12.

On the other side of the carrier, there is placed a pair of opposed grounded terminals 15.

At this point, it should be understood that the terminals 15 may be charged and the terminal 14 grounded. I may also use a pair of charged terminals 15 and a pair of grounded terminals 14 or vice versa.

In lieu of these expedients, I may also employ reversely charged terminals wherein the electrode or electrodes below the web will be charged negatively and the electrode or electrodes above the web are charged positively, from a suitable source of high potential, or vice versa.

Referring to the drawing, the terminals 15 are preferably disposed out of the normal gravitational path of the sand column and at a suitable distance, depending upon the voltage employed, from the electrode 14 as to produce a thoroughly satisfactory electrical field. The electrode or ground 14 is preferably placed in close proximity to the under surface of the backing as shown, but the spacing of the various terminals or electrodes with respect to each other and to the carrier may be varied in accordance with the product being made, the strength of the field and the nature of the particles.

In the embodiment shown, the intensity of the electrical field will be greatest at and about the point where the lines of force created between the terminals 15 and the electrode 14 converge, namely at and about the sand column where it contacts with the web.

By employing such a construction the particles are attracted to the backing by the electrode 14, at the same time acquiring a charge which causes them to be mutually repellent and hence shower or fan out.

By reason of the electrical field created in any of the several ways described, the control of the deposition of the particles upon the web is very efficiently cared for.

Thus the intensity of the field is greatest at and about the point of contact of the sand column with the web and I am enabled to obtain (a) a uniform dispersion to produce a level sand distribution having a maximum number of cutting points, (b) an orientation such that the particles are positioned with their longest axes and sharpest edges producing a maximum cutting effect, and (c) a stratification or classification whereby the coarser fractions are disposed in the top plane where they produce an optimum abrading result.

It will be understood that with the feed of the particles regulated from the hopper by means of

the gate 11 to accord with the character of sand paper it is desired to produce, that the particles will be propelled by gravity to a point adjacent the continuously moving backing above the electrode 14 and between the terminals 18, reaching the paper or web at the point of conversion of the lines of force created by the electrodes or terminals and which is the point of greatest electrical intensity. Thus a field is produced at and about the sand column which creates the repellent action of the particles and causes them to fan-out in a definite manner, depending upon the strength of the field which may be regulated to alter the effect.

I have illustrated in the drawing two shields 16 disposed adjacent the backing and which extend across the transverse area thereof. These shields in some cases are useful to confine the particles in the event there is an undue fanning-out or showering and are preferably made of insulated material or suitably insulated. I also place beneath the electrode 14 a shield 17 of insulated material and the respective shields cooperate in addition to confining the particles, to enhance the intensity of the electrical field produced through the medium of the several electrodes or terminals. These shields, of course, may be omitted but I find them very satisfactory for both functions recited.

While I have referred herein to sand as the abrasive medium, it will be understood that other abrasives of a particle nature are operable in accordance with this invention.

The electrodes, as stated, may be arranged in various ways and their spacing with respect to each other and to the backing, may be varied at will in accordance with the character of the coating desired, the strength of the field and the particular article which is being made.

It will be understood that the invention enables a very careful and accurate control to the end that a uniform dispersion, orientation and stratification are obtained and an article having optimum abrading efficiency is formed.

What I claim is:

1. In an apparatus of the class described comprising a feeding means for abrasive particles, means for supporting a carrier having an adhesive surface to be coated with said particles below said feeding means, and means for forming an electrical field comprising terminals on one side of the carrier between which the particles pass in their path to the carrier and a terminal of opposite polarity on the other side of the carrier disposed substantially intermediate the said first mentioned terminals, whereby to narrow and intensify the field at the point of disposition of the particles upon the carrier.

2. An apparatus of the class described comprising a gravity feeding means for abrasive particles, means for supporting a backing having an adhesive surface to be coated with said particles, an electrode disposed in close proximity beneath the backing when the latter is supported on said means, and a pair of spaced terminals disposed on the other side of the backing and creating with said electrode a substantially V-shaped electrical field embracing the abrasive column at and about its point of contact with the carrier.

3. An apparatus of the class described comprising a feeding means for abrasive particles, means for supporting and continuously moving a carrier having an adhesive surface to be coated with said particles, a terminal disposed in close proximity beneath said carrier when supported on said means, and a pair of spaced terminals disposed above said carrier between which the particles are adapted to pass in their path to the carrier, the respective terminals creating a substantially V-shaped electrical field having its greatest intensity at and about the point of contact of the abrasive column with the carrier.

4. An apparatus of the class described comprising a feeding means for abrasive particles, means for supporting and continuously moving a carrier having an adhesive surface to be coated with said particles, a terminal disposed in close proximity beneath said carrier when supported on said means, and a pair of spaced terminals disposed above said carrier between which the particles are adapted to pass in their path to the carrier, the respective terminals creating a substantially V-shaped electrical field having its greatest intensity at and about the point of contact of the abrasive column with the carrier, and shields of insulated material disposed adjacent the carrier and about the electrode beneath the carrier.

5. In an apparatus of the class described comprising a feeding means for abrasive particles, means for supporting a carrier having an adhesive surface to be coated with said particles, and means for forming an electrical field comprising terminals of opposite polarity on opposite sides of the carrier, said terminals cooperating to narrow and intensify the field and converge the same at the point of disposition of the particles upon the carrier.

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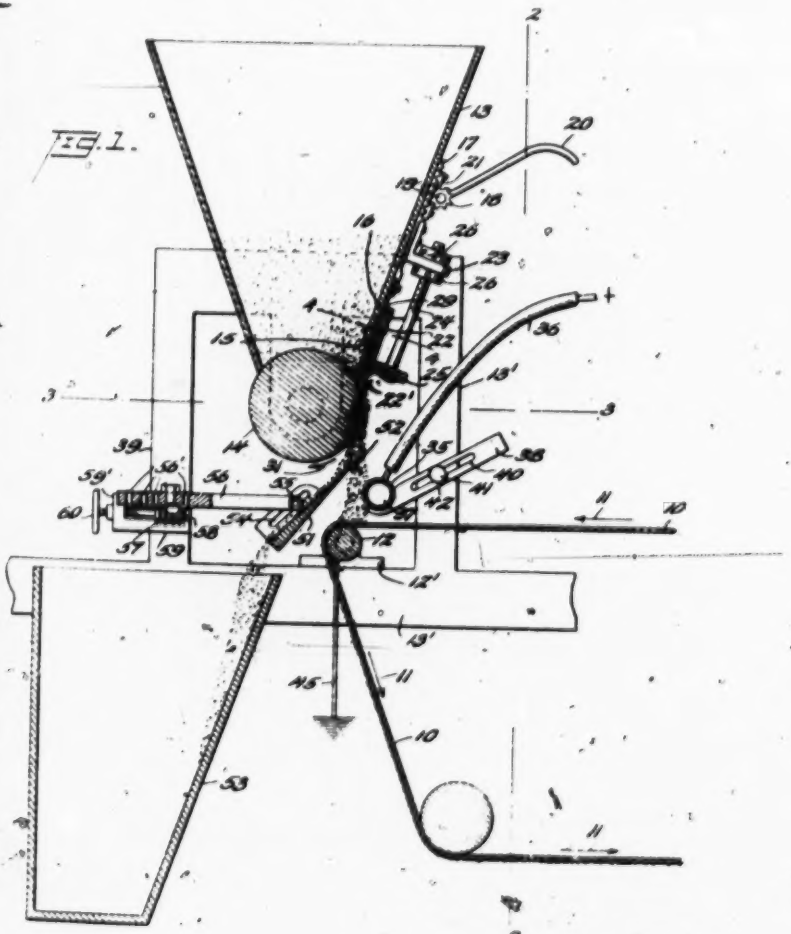
Jan. 7, 1936. E. C. SCHACHT 2,027,308

ABRASIVE MATERIAL

Filed March 24, 1932 3 Sheets-Sheet 1



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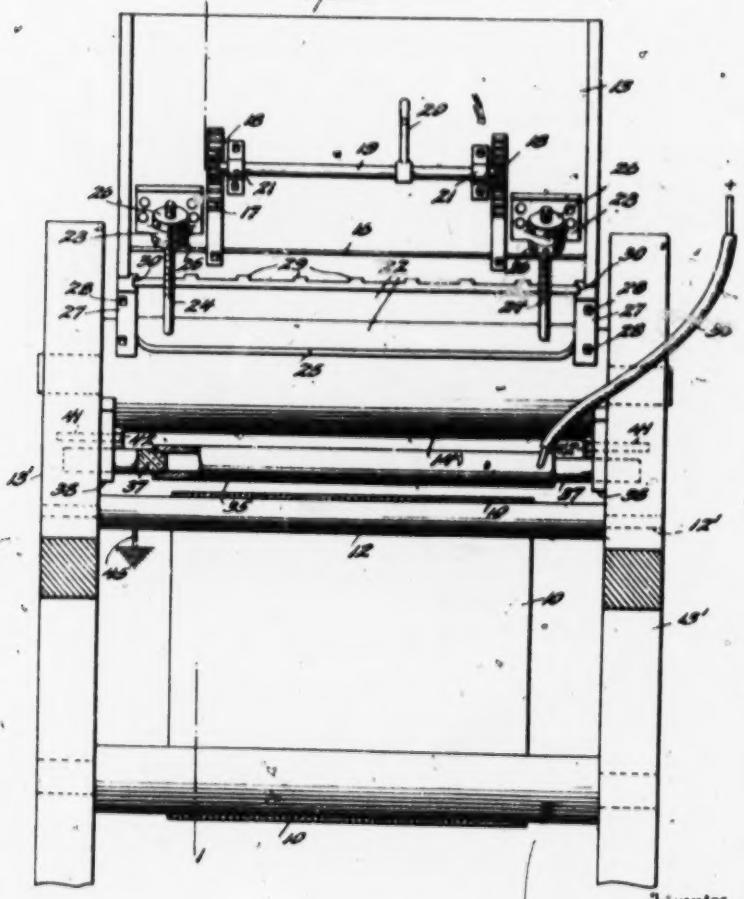
Jan. 7, 1936. E. C. SCHACHT 2,027,309

ABRASIVE MATERIAL

Filed March 24, 1932 3 Sheets-Sheet 2

FIG 2.



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ABRASIVE MATERIAL

Filed March 24, 1932 3 Sheets-Sheet 3

FIG. 3.

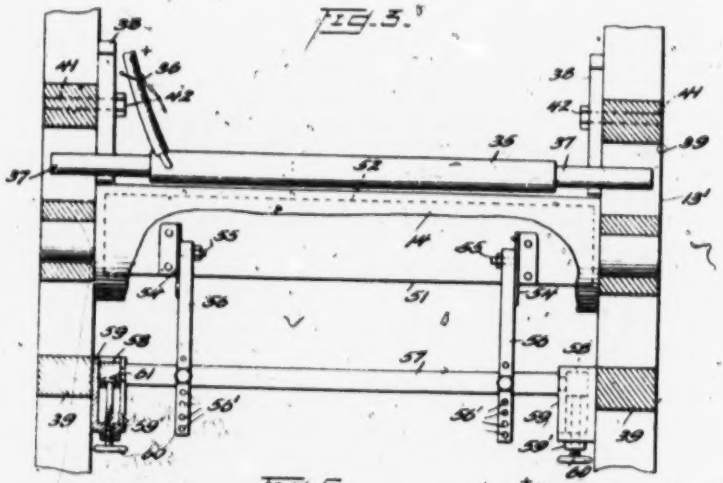

FIG. 6.

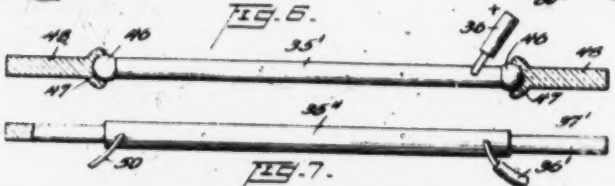

FIG. 7.

FIG. 4.

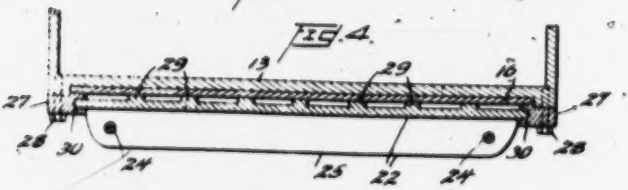

FIG. 5.

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UNITED STATES PATENT OFFICE

2,027,309

ABRASIVE MATERIAL

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Application March 24, 1933, Serial No. 661,961

1 Claim. (Cl. 51—188)

This invention relates to the art of coating with finely divided or fragmentary material.

An object of the invention is to provide an abrasive article in which the abrasive particles are individually oriented thereon i. e., with their major axes arranged substantially perpendicularly to the carrier for the particles so that their sharpest portions are exposed.

A further object of the invention is to provide an abrasive article in which the particles are stratified in accordance with their size.

A further object of the invention is to provide an abrasive article in which the particles are secured to the base by means of adhesive and individually oriented and stratified according to their size.

The invention contemplates an arrangement or distribution control which will effect proper distribution or dispersion of the particles with reference to one another, and preferably also the proper positioning or orientation of each individual particle, so that in providing a coated surface of abrasive material, for instance, the particles are arranged with their major axes substantially perpendicular to the carrier with the result that the sharpest portion of each particle will be exposed.

The method and apparatus will be described in their application to the manufacture of an abrasive paper, such as sand paper, although it will be understood that while particularly useful in the manufacture of such material, the invention is not limited in broader aspects to this particular field.

Abrasive paper, by which is meant any abrasive sheet or strip material having an abrasive surface formed of abrasive particles, ordinarily consists of a backing or carrier of paper or fabric, or combined paper and fibric, which is first provided with an adhesive surface upon which the abrasive or cutting material, such as sand, is then deposited.

Abrasive paper is of two general types. In one type, the adhesive surface of the carrier or backing is completely covered with the abrasive grains or fragments. The individual grains are closely packed, so that virtually no portion of the backing surface is exposed. Such a coating of abrasive material is commonly called a "closed coating".

In the second type, the individual particles or grains are spaced apart as uniformly as possible over the surface, so that substantially all of the particles stand by themselves alone or as units of the abrasive surface. Such a coating of abrasive material is termed an "open coating".

The open coating is considered preferable for abrasive paper in some usages, since it does not tend to load or become packed with the material which is abraded. In some cases, a closed coating, in which the interstices between the individual grains are extremely small, and virtually non-existent, quickly becomes loaded or embedded with the material abraded, and this results in excessive friction and finally the burning of both the abrasive and abraded surfaces. Such loading and burning is especially noticeable when abrading soft materials or materials of a gummy or resinous nature. The open coating overcomes this objection, since in view of the substantial space around each of the abrasive grains, the abrasive surface does not become packed, and the particles removed from an abraded object do not remain in the interstices between the individual grains.

In the manufacture of both types of coating, it is preferable to arrange or orient the individual grains so that their major axes are substantially perpendicular to the carrier with the result that their sharper and more pointed portions are exposed. Furthermore, in the formation of an open coating, it has always been a problem to obtain the desired arrangement or dispersion of the individual grains with reference to one another. This dispersion or spacing of the individual particles is a problem particularly important in the formation of an open coating, but the proper distribution of the particles as they are deposited upon the carrier is also important in the manufacture of a closed coating. In the manufacture of the closed coating, it is customary to drop or deposit upon the adhesively coated carrier a greater amount of abrasive than it can hold. The surplus is then removed. Consequently, the only control as to the amount of abrasive retained is the holding capacity of the adhesive. In order to control accurately the amount of abrasive applied on a closed coating, it is, therefore, important to see that the surface is uniformly covered, and due to this it is necessary that the particles be uniformly distributed at the instant the abrasive is applied to the adhesive. When the particles are simply dropped on the adhesively coated carrier and no dispersing method employed, the resultant surface reflects any irregularities which are present in the fall or passage of the sand, and these irregularities produce streaks or ridges in the coating. It has also been found that there is a tendency in dropping sand or other abrasive particles for

[fol. 558]

the latter to bunch together and produce what is called a lumpy or bunchy coating which greatly impairs the cutting efficiency of the sheet because there are created a multiplicity of small high areas which come in contact with the surface to be abraded. Obviously, these areas keep much of the abrasive out of contact with the surface being abraded, and thus reduce the efficiency of the sheet.

It will be understood, therefore, that by the terms "disperaion" or "arrangement", as applied to the particles, is not meant any particular spacing of the particles relative to one another, since the particles are "dispersed" or "arranged" relative to one another regardless of whether an open or closed coating is being formed. So far as the method of this invention is concerned, the difference between an open and closed coating resides solely in the extent or degree to which the electrostatic field is used, i. e. a stronger field or different disposition of the same is employed to produce an open coating than a closed coating. But in the manufacture of both types of coating, the electrostatic field may be effectively employed to produce the desired arrangement or dispersion of particles in the abrasive stream.

Heretofore, it has been the common practice to supply the abrasive material, such as sand, from a hopper by means of a feed roll having associated therewith an adjustable gate which controls the feed of sand. In the use of coarser grades of sand or abrasive material, such a means for controlling its application has been found to be effective, to a certain extent, since coarse sands will not bind or pack between the gate and the feed roll and will flow uniformly between the gate and roll to produce an open coating upon the carrier. However, it has been observed that this expedient does not effectively guarantee the uniformity of particle distribution or the equalization of density throughout the different areas, and, moreover, it has no effect upon the sharpness of the abrasive surface produced, and does not have a tendency to arrange each individual particle so that its sharpest portion or point is exposed.

In the use of fine abrasive material, such as number 240 sand, a feed gate and roll or similar apparatus does not produce a uniform flow, even though the gate and feed roll surfaces are finely ground and brought extremely close together. The difficulty is particularly due to the tendency of the sand to pack or bind in the gate. As a result, the abrasive surface is characterized by bare spots, blotches, bars and streaks.

Consequently, in the manufacture of abrasive paper from fine abrasive material, it is necessary to exercise extreme care to obtain a uniform flow of sand and to finely grind and adjust both the gate and feed roll.

The present invention seeks to provide an improved means for obtaining proper arrangement of the sand both with respect to the uniform dispersion or spacing of the particles relative to one another, and also with respect to the arrangement or orientation of each particle considered individually to arrange each particle with its major axis substantially perpendicular to the carrier and expose its sharpest portion.

The invention also contemplates an improved apparatus for carrying out this method.

Essentially, the invention comprises the use of an electrical charge produced by an electrostatic field, which is arranged so as to influence the individual sand particles to obtain the proper distribution of the same over the surface, and also preferably, to position each particle so that its sharpest and therefore most effective abrasive portion is exposed.

The invention also contemplates the use of the electrical field in such a manner that the stream of abrasive particles, as it flows toward the carrier, is controlled by the electrical field so as to cause a uniform distribution of the same relatively to one another, and thus produce a misting of the particles over a much greater area and eliminate ridges and streaks as well as the bunchiness or lumping in the coating.

In providing the electrostatic field, the invention seeks to dispense with the necessity for accurately grinding and spacing the gate and feed roll. It has been found preferable to dispose the field so that it will affect the sand as it travels toward the surface of the carrier to be coated, thus permitting the field to disperse the entire sand-shower. The method also contemplates the selecting off from the dispersed or electrified shower, as by means of a baffle, any excess sand not desired, and permitting the remainder to drop with the particles in their properly dispersed relation and also individually oriented, i. e. sharpest points up, upon the adhesive surface. By properly arranging the electrostatic field, the method will also maintain a predetermined relation between each particle and it is oriented, i. e., with its major axis disposed substantially perpendicular to the carrier, in the field until it is united with the surface, thus obtaining exposure of the sharpest and most abrasive portion of each particle.

In carrying out the method, a supply of sand may be arranged in a hopper above an adhesively surfaced carrier or backing. The hopper may, if desired, be provided with an adjustable gate and feed roll for controlling to a certain extent the showering of the sand upon the adhesive surface to be coated, although the sand may be dropped toward the carrier in surplus quantities. The electrostatic field is disposed between the carrier and gate, so that the sand must travel through or adjacent the field before it reaches the carrier.

The sand particles are each influenced by the electrical charge, which serves to fan or spread out and disperse the shower, maintaining the particles in substantially uniformly spaced relation until they reach the carrier. It will be found that the voltage or power of the field may be regulated to control the extent to which the particles are fanned out or dispersed, and, of course, a factor in this control will be the character of the coating desired. If a closed coating devoid of ridges or bunchiness is desired, the field will be of a character which will simply provide the uniform distribution necessary to prevent these defects. If an open coating is required, the field will be controlled so as to disperse the particles relatively to one another to a greater extent. If the sand is showered in surplus quantities, a baffle or diverting plate may be suitably arranged to divert from the normal path of the shower any portion thereof which it is desired to exclude from the carrier. The position of the baffle will, of course, vary depending upon the character of the coating desired, and the amount of sand being showered toward the carrier surface.

The particles not led off from the shower continue on to the carrier and fall upon its adhesive surface. Due to the dispersing action of the electrostatic field, the particles are deposited upon this surface in substantially uniformly spaced relation, thus providing an ideal open coating.

When applied to an abrasive medium such as sand, the electrostatic field has been found to be extremely efficient, and even though the controlling gate is opened quite wide to overcome the packing tendency of fine sands, and to provide a flow in excess of that required to use a coating, the use of, the field will properly disperse the entire shower from which may be led off such excess portions as are not to be permitted to fall upon the adhesive surface. The use of such an excess flow eliminates the necessity for maintaining the gate and feed roll accurately ground or adjusted, and moreover, the irregularities of sand flow due to surface imperfections on the gate or roll have been found to be relatively small in relation to the large amount of sand flowing.

As will be understood, the deposition of the particles upon the carrier uninfluenced by any force which tends to oppose the effect of the electrostatic field, except, of course, the weight of the particles themselves, permits the field to effect desired control of position and the particles are, as a result, arranged upon the carrier under the influence of the field substantially unaffected by any other force.

Furthermore, it has been found that the resultant abrasive surface is much sharper than a surface produced by simply dropping the material upon the carrier, even though attempts may be made to control the arrangement of the same by other media than electrical means.

In obtaining the proper orientation of each individual particle with its sharpest portion exposed, it is thought that the field causes substantially each particle to align itself so that its longest axis is virtually parallel to the lines of force of the field or, in other words, substantially perpendicular to the carrier surface. The rate of discharge of an electrostatic charge is dependent upon the surface characteristics of the charged body, and the larger the radius of curvature, the slower the rate of discharge, and the sharper the point, the faster the rate of discharge. It is believed that this relation of the rate of discharge of the surface characteristic of the charged body, e. g. sand grain with a pointed abrasive portion, causes the sharpest points of the grains to orient themselves so as to discharge in the direction of the field, with a result that since the lines of force of the field intersect the carrier, the particles are deposited upon the surface with their sharpest points directed toward the electrostatic field, and away from the supporting surface. Consequently, the points are made to project outwardly, and the resultant coating is very much sharper than a coating made without the use of an electrical force for orienting or arranging each individual particle. Obviously, of course, such an arrangement or orientation of the particles is useful in either a closed or open coating, since it (1) increases the sharpness of the coating and enables faster and easier cutting, (2) minimises heating and loading, and (3) increases the cutting life or capacity of the abrasive surface.

Moreover, it will be clear that the use of the electrostatic field in the formation of a closed coating prevents lumping or bunching of the sand by distributing the same over the entire area or surface to be coated. It blends out the irregularities which would otherwise develop in the stream due to lack of uniformity in the feed gate and to other factors which modify the effect of gravity, or other means which may be used to direct the stream to the carrier.

It will be understood, of course, that the electrostatic field can be used as a dispersing means with any type of particles whether abrasive or non-abrasive, to insure a uniform distribution, and irrespective of the nature of the substance or carrier upon which they are being deposited.

In the manufacture of sand paper, the electrostatic field is particularly useful. Although, in producing any particular grade of paper the particles are of approximately equal size and weight, it has, for many years, been the practice to use particles known as (a) control, (b) undergrade, and (c) overgrade; the control particles predominate. It has been found that the electrostatic field utilized in the manner herein described tends to stratify the particles and cause to locate on the top surface the larger particles, that is, the particles having larger areas of cutting surface.

It will be understood, therefore, that the control or change of position of the various particles effected by the field has three characteristics: First, the particles are oriented or turned by the lines of force, so that their major axis are substantially perpendicular to the carrier surface or parallel the lines of force of the field with the result that the sharper surfaces of the abrasive coating are exposed. Second, the various particles are stratified so that the larger or more effective particles are on the surface. Third, the particles are dispersed to produce a more uniform coating, due to the fact that they are mutually repellent.

The dispersion of the particles is caused by the fact that, as they enter the field, they acquire a charge of the same polarity as one of the electrodes of the field, and since all of the particles have been graded to approximately the same size, although some are undergrade, some are overgrade and others are control particles, they all acquire a charge of approximately equal intensity and of the same polarity. Hence, all of the particles in any shower, as they pass through the field, are mutually repellent with substantially an equal repelling force, and thus arrange themselves so that they are substantially equidistant in all directions. This repellent action is effected not only as the particles pass through the field, but on the carrier.

It is preferred that the electrical field be arranged at the point of deposition of the particles, so that this control of position is exercised at the point of deposition and at the time the particles strike the carrier. As a consequence, the positions of the particles will be controlled before the adhesive has set and will be effected on the carrier as well as in the path of the particles to the carrier.

In practicing the method, various forms of apparatus may be employed, and in the accompanying drawings showing a preferred form:

Figure 1 is a vertical sectional view on substantially the line 1—1 of Figure 2.

Figure 2 is a vertical sectional view on the line 2—2 of Figure 1.

Figure 3 is a horizontal sectional view on the line 3—3 of Figure 1, with the feed roll shown in elevation, and partly broken away.

Figure 4 is a fragmentary sectional view on the line 4—4 of Figure 1.

Figure 5 is a cross sectional view of a modified form of discharge electrode.

Figure 6 is an elevational view of a modified form of discharge or high potential electrode having its ends forged to eliminate "end effect", and

[fol. 560]

Figure 7 is a top plan view of another form of discharge electrode.

Referring to the accompanying drawings for a more detailed description, 10 indicates the carrier or paper sheet which may be fed in the direction of the arrows 11 by suitable means (not shown) over a roll 12 having end bearings in brackets 12' on the frame 13'. As will be understood, the paper has an adhesively coated top surface exposed to receive sand or other abrasive material dropped from a hopper 13, the lower end of which is partly closed by a feed roll 14. A wall of the hopper terminates at 15, a short distance above the feed roll to provide a discharge opening for the sand, which may be entirely closed by means of a shut-off gate 16 operable by means of a pair of rack bars 17 engaged by gears 18 upon a rock shaft 19, the latter carrying an operating lever 20 and being mounted in bearings 21 upon the wall of the hopper. The gate 16 is provided for the purpose of entirely shutting off the supply of sand when desired, and a second regulating gate 22 for adjusting the size of the opening between the lower end of the gate 16 and the periphery of the sand roll is adjustably mounted in brackets 23 by means of adjusting rods 24 secured to an outwardly extending rib 25 upon the gate, and extending through openings in the bracket. Clamping nuts 26 on opposite sides of the bracket webs through which the bolts 24 extend serve to secure the gate in any set position. As will be observed from Figure 4, the shut-off gate 16 is arranged between the regulating gate and the hopper wall, and it fits closely in a slideway formed by strips 27 secured to the hopper by bolts 28. The regulating gate 22 is provided on its rear surface with ribs 29 which abut the face of the shut-off gate and assist in providing a guideway for the same.

As the regulating gate is adjusted by means of the adjusting bolts 24, it is adapted to slide in grooves 30 (Fig. 4) formed in the strips 27 secured to the hopper.

When sand or other finely divided abrasive material is arranged within the hopper, operation of the feed roll in the direction of the arrow 31 (Fig. 1) after the shut-off gate has been opened and the regulating gate has been suitably adjusted, will cause the sand to drop downwardly in a shower toward the exposed adhesively coated surface of the carrier 10.

The amount of sand discharged between the periphery of the sand roll and the end 22' of the adjusting gate 22, will, of course, depend upon the adjustment of the gate.

An electrostatic field may be formed by means of a tube 35 connected, as by means of a lead wire 36, to a source of high voltage (not shown). The tube 35 may be supported at its ends by means of insulating posts 37 carried by brackets 38 upon the frame 13'. The brackets 38 may be provided with elongated slots 40 receiving bolts 41 with clamping nuts 42, whereby the position of the electrode may be varied as desired. The zero or ground potential side of the field may be provided by means of the paper carrying roll 12 which may be formed of suitable material and connected with the ground, as by means of a lead 43. The field formed by the tube 35 and roll 12 may be varied in intensity and extent, as desired. For instance, it is possible to make a field of higher unit intensity by reducing the diameter of the tube 35, or a broader field and one of lower unit intensity, by increasing the diameter of the electrode 35. Moreover, the proximity of ground or zero potential effects the field, and if desired, a multiplicity of tubes 35 may be employed.

In order to avoid "end effect", the ends of the tube may be rounded, as illustrated in Figure 6, wherein the tube 35' is provided with rounded ends or heads 46 which are seated in sockets 47 provided in the insulating post 48.

Furthermore, it has been found at times that by moving the tube 35, as by rotation, will have a pronounced effect upon the character of the field, and that instead of the tube 35, a solid rod may be employed if desired. In some instances, instead of a hollow tube, a wire brush, or a series of wires, such as piano wires, have been found to provide efficient electrodes and to alter the character of the electrostatic field to meet specialized conditions in the application of abrasive material.

Another modified form of electrode is shown in Figure 7, wherein the electrode is provided at one end with a substantially horizontally extending rigid strip 50 of metal, such as copper, wire or brass, and at the other end, the lead 36' is directed substantially horizontally, and is exposed for the purpose of providing in effect angularly bent ends of the electrode tube 35'', which may be supported upon the insulating posts 37'. The strip and exposed lead wire being directed toward the sand shower at an angle of about 45° to the tube, serve to decrease "end effect" and to fan out the edge of the sand shower, which, as will be understood, in dropping upon the abrasive material passes through the field. As the sand enters the electrostatic field, the particles are dispersed, and in such dispersed relation are deposited upon the adhesive surface of the carrier 10. The effect of the field is to fan out or spread the shower of sand, as illustrated in Figure 1, and ordinarily it has been found that it is preferable to position the regulating gate 22, so that an excess or surplus amount of sand is discharged from the hopper. In order to divert from the normal path of flow such quantity as should not fall upon the carrier, a baffle or diverting plate 51 is positioned with its surface inclined upwardly toward the feed roll, and with one edge 52 entering the shower of sand. This baffle serves to direct a portion of the shower over its surface downwardly into a hopper 53, from which the sand may be removed as desired.

In order to provide suitable means for varying the position of the baffle, so that the amount of sand selected off from the shower may be accurately regulated, the baffle is provided with a pair of upstanding slotted lugs 54, into the slots of which project clamping bolts 56 carried by adjusting arms 58 (Figure 3) which are positioned upon a cross head 57 having end blocks 58 slidably mounted in brackets 59 upon the frame 39. Adjusting screws 60 are threaded in walls 59' of the brackets 59 and have heads 61 swivelled in the boxes 59. As will be understood, manipulation of the screws 60 will guide the blocks and cross head 57 toward and from the sand shower, and thus move the baffle horizontally. The angular portion of the baffle may be varied at the clamping bolts 56, and as will be observed, the arms 54 are provided with a series of openings 54' so that their effective length may be altered.

In Figure 8 there is shown a modified form of electrode comprising an electrified tube 62, which is arranged within a tube 63 of considerably larger diameter and in electrical contact with the electrified tube, by which it is supported. The outer tube considerably enlarges the effective diameter

of the electrode, and as will be understood, broadens the field produced. The rod 32 may be connected to a source of high voltage in any suitable manner (not shown).

In operating the apparatus, the position of the baffle 34 will, of course, determine the portion of sand showered from the hopper which will be permitted to fall upon the adhesive surface. As has been explained, instead of bringing the end 22' of the gate close to the feed roll, even with extremely fine sands, in order to determine the exact amount of sand necessary to make the coating desired, the gate is preferably opened sufficiently wide to overcome the packing tendencies of said sands and to obtain a uniform flow, which is in excess of that required to produce a satisfactory coating. The comparatively heavy flow of sand eliminates the necessity for keeping the gate and feed roll perfectly ground, because the irregularities in the sand flow due to surface imperfections on the gate or roll, are very small in proportion to the large amount of sand flowing. As the sand stream leaves the gate, it passes within the influence of the electrostatic field, and immediately causes a dispersion of the particles or a fanning out or widening of the stream or shower. As has been explained, this dispersion can be varied by changing the characteristics of the field by any of the means described. Moreover, varying the voltage controlling the field will control the dispersing action of the same. The adjustment of the baffle 34 will regulate the amount of the shower, which is diverted from the path toward the surface to be coated, and in ordinary practice, it will be found that the control of the amount of grain applied and the character of the coating may be effectively controlled by varying the voltage without making adjustments in the apparatus. As will be understood, the abrasive material may be deposited in any degree of depth, from an extremely thin deposit approximately one particle thick to a thick deposit, and in any coating particles will not only be distributed with great uniformity, but will individually oriented or deposited with their major axes at right angles to the abrasive surface.

As will be observed (Fig. 1) the abrasive coated carrier passes from the electrostatic field and is conducted away without mechanically or otherwise compacting the surface, thereby leaving the particles uniformly distributed and individually oriented in which condition they are, of course, maintained.

Since the tube 38 is sufficiently long (Fig. 2) to extend beyond the edges of the paper, the sand will be uniformly applied throughout the entire width of the same, and by properly regulating the speed of travel of the paper, the sand may be continuously applied as the paper travels over the roll 12 to a take-up roll (not shown).

By the expression "adhesively retaining" as used with reference to the retention of the particles upon the carrier, is meant the use of means other than electricity for retaining by adhesive action the coating material upon the carrier. By "abrasive" is meant any abrasive or coating material in fragmentary form; by "carrier" is meant any desired material or support on which the fragmentary or divided material may be superimposed or deposited; by "controlled" or "regulated" as applied to the supply or feed of finely divided material to the carrier is meant simply that the material is supplied in such a way as to be responsive to the action of the electrical field for the result desired, whether dispersion or orientation or both.

Obviously, numerous modifications may be made in the structure illustrated and described without departing from the invention, the essence of which is more definitely set forth in the following claim.

This application is a division of my co-pending application Serial No. 290,233, filed July 30, 1928.

What I claim is:

A new article of manufacture having abrasive particles positioned relative to one another by electric action, substantially all of the abrasive particles at the abrading surface being substantially uniformly spaced apart and having major and minor axes and being responsive to electric action, substantially all of said particles being positioned and supported in an adhesive with their major axes substantially perpendicular to the abrading surface.

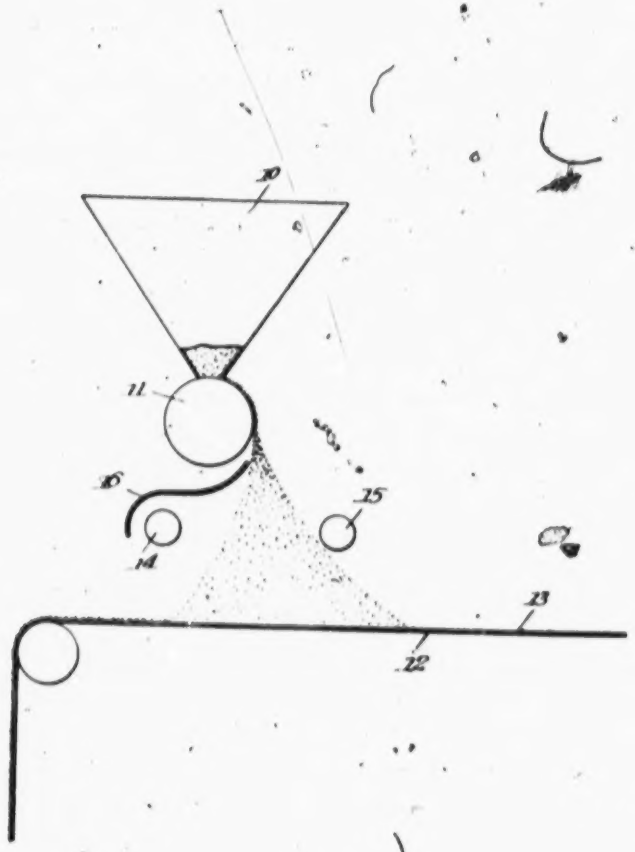
BLAKER C. SCHACHT.

[fol. 562]

June 1, 1937. E. C. SCHACHT 2,082,182

MANUFACTURE OF ABRASIVE ARTICLES

Filed Nov. 20, 1931



Inventor

Elmer C. Schacht.

By Cushman, Darby & Cushman

Attorneys

Patented June 1, 1937

2,082,182

UNITED STATES PATENT OFFICE

2,082,182

MANUFACTURE OF ABRASIVE ARTICLES

Elmer C. Schmidt, Troy, N. Y., assignor, by mesne assignments, to Behr-Manning Corporation, a corporation of Massachusetts

Application November 30, 1931, Serial No. 578,414

4 Claims. (Cl. 91—68)

My invention relates to the manufacture of abrasive articles and is particularly concerned with the production of flexible abrasive material of which one example is sand paper.

An object of the invention is to produce a sand paper having a maximum abrading efficiency by means of a process wherein the particles are dispersed to form a uniform coating upon the adhesive surface of a web or carrier.

I have found that if an electrical field be provided between a hopper or other feeding source and the web to be coated, which field will be so disposed that the lines of force cross the gravitational path of the particles and preferably parallel to the surface of the carrier, the particles will acquire a charge rendering them mutually repellent and in addition to the gravitational force, will be controlled by the action of the lines of force both in their movement to the web and in the manner in which their positions are controlled upon the adhesive surface of the web.

By reason of the present invention, there is obtained a uniform dispersement to produce a level sand distribution having the maximum number of cutting points.

The invention is applicable in the manufacture of both "open coated" and "closed coated" sand paper and may be used with varying grades and sizes of particles.

In the drawing:

The figure is a diagrammatic view of the invention.

Referring to the drawing, the numeral 10 indicates a hopper in which are disposed the abrasive particles which are preferably usually employed in the manufacture of sand paper.

The particle mixture comprises the customary "under grade", "control grade", and "over grade" in which the "control grade" predominates.

Disposed below the hopper is a suitable gate 11 which will preferably be adjustable, so as to control the feed of the particles from the hopper. The particles are released from the hopper in controlled amounts to a web 12, which is preferably provided with an adhesive surface 13. The web may consist of paper, cloth or a laminated material composed of paper and cloth, or in fact any usual backing or carrier known in the art employed.

Disposed with its lines of force directed transversely across the gravitational path of the particles between the feed roller 11 and the horizontally disposed web 12, is an electrical field created from a source of high potential.

At this point it will be observed that the web 12 is continuously fed in a preferably horizontal direction in accordance with the arrow, being supported and carried over suitable rollers 11, and that the lines of force created by the electrical field are substantially parallel to the web.

The field is created by reason of the spaced electrodes 14 and 15, one of which will be charged and the other grounded. In the present instance, I have shown the electrode 14 as negatively charged and the terminal 15 grounded. Obviously this arrangement can be reversed.

The lines of force of this field, as stated, are parallel to the surface of the carrier and are disposed entirely at one side thereof and in the present instance above the carrier.

The strength of the field will be varied in accordance with the nature of the particles and the character of the coating required, and can also be varied in accordance with the distance of the field from the web.

It should be understood also that the feed of the particles may be regulated in accordance with the strength of the electrical field.

Upon reference to the drawing, it will be observed that by reason of the lines of force set up in the field, the particles become charged and thus mutually repellent, causing them to shower or fan-out.

By reason of this process, I obtain a uniform dispersement to produce a level sand distribution having maximum number of cutting points.

The electrodes 14 and 15 may be a greater or less distance apart, depending upon the article to be prepared, and the nature of the abrasive particles and, as stated, the strength of the field may be varied.

By reason of the process, the web having an adhesive surface is continuously coated and it is only necessary that the feed and the strength and position of the field be suitably regulated, whereas the positions of the particles is controlled.

In some cases, I find it desirable to employ a screen or shield 16 to confine the particles, although this is not essential.

My invention is adapted for the production of either "open coated" or "closed coated" paper and while I have referred herein to sand specifically as the abrasive material, it will be understood that other abrasives of a particle nature are equally with this invention.

It will be clear that the gravitational feed of the particles from the hopper 10 and feed roller or gate 11, causes them to enter the electrical field and pass therethrough. Upon becoming charged the particles are mutually repellent and

[fol. 564]

their direction is changed from that due to the gravitational force alone, to a resultant which is the combined effect of the gravitational force and the respective repellent actions of the particles to each other, plus the action of the lines of force. In this manner, the disposition of the particles upon the carrier is controlled to produce the desired effects of uniform dispersement, resulting in an abrasive surface having the particles permanently associated and possessing a maximum cutting efficiency.

What I claim is:

1. In the art of preparing abrasive articles, wherein abrasive particles are deposited upon the adhesive surface of a backing, the steps which comprise feeding the particles as individually separated bodies to and through an electrical field in which the electrodes creating the same are disposed entirely at one side of the carrier whereby the particles must pass through the field in their travel to the carrier, and passing the particles from the field to adhesive surface of the backing in a direction constituting an alteration of the action of the gravitational force due to the mutual repulsiveness of the particles and to the lines of force created by said field whereby the particles are applied to the adhesively coated backing in dispersed relation.

2. In the art of preparing abrasive articles, wherein abrasive particles are deposited upon the adhesive surface of a backing, the steps which comprise feeding the particles as individually separated bodies to and through an electrical field in which the electrodes creating the same are disposed entirely at one side of the carrier and having its lines of force parallel to the surface whereby the particles must pass through the field on their way to the carrier, and passing the particles from the field to the adhesive surface of the backing in a direction constituting an alteration of the action of the gravitational force due to the mutual repulsiveness of the particles and to the lines of force created by said field whereby the particles are applied to the adhesively coated backing in dispersed relation.

3. In the art of preparing abrasive articles, wherein abrasive particles are deposited upon the adhesive surface of a backing, the steps which comprise continuously feeding the particles as individually separated bodies to and through an electrical field in which the electrodes creating the same are disposed entirely at one side of the carrier whereby the particles must pass through the field in their travel to the carrier, and passing the particles from the field to a continuously moving backing having an adhesive surface in a direction constituting an alteration of the action of the gravitational force due to the mutual repulsiveness of the particles and to the lines of force created by said field whereby the particles are applied to the adhesively coated backing in dispersed relation.

4. In the art of preparing abrasive articles, wherein abrasive particles are deposited upon the adhesive surface of a backing, the steps which comprise continuously feeding the particles to and through an electrical field in which the electrodes creating the same are disposed entirely at one side of the carrier and having its lines of force parallel to the surface whereby the particles must pass through the field on their way to the carrier, and passing the particles from the field to a continuously moving backing having an adhesive surface in a direction constituting an alteration of the action of the gravitational force due to the mutual repulsiveness of the particles and to the lines of force created by said field whereby the particles are applied to the adhesively coated backing in dispersed relation.

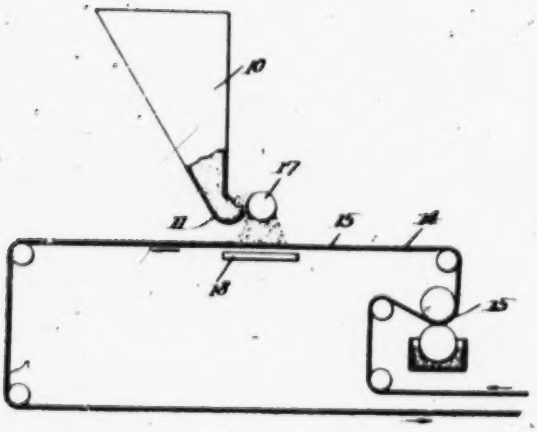
ELMER C. SCHACHT.

[fol. 565]

June 10, 1941. E. C. SCHACHT 2,245,301

MANUFACTURE OF ABRASIVE ARTICLES

Filed Nov. 20, 1931



Inventor

Elmer C. Schacht,

By Carlton Bryant & Rothschild

Attorneys

[fol. 566]

Patented June 10, 1941

2,245,301

UNITED STATES PATENT OFFICE

2,245,301

MANUFACTURE OF ABRASIVE ARTICLES

Elmer C. Schacht, Troy N. Y., assignor, by mesne assignments, to Behr-Manning Corporation, a corporation of Massachusetts

Application November 20, 1931, Serial No. 576,613

3 Claims. (Cl. 91—18)

The present invention relates to the manufacre of abrasive articles and is primarily concerned th the production of flexible abrasive material, which sand paper is one example. The process the present invention consists briefly in emoying an electrical field as the sole means of opelling the particles of abrasive to the back- or carrier whereby at a single step the backing ll be coated with a uniformly dispersed layer abrasive, oriented and stratified to produce an icle having an abrasive surface of maximum ciency.

The process is distinguished from prior methods erein electrically charged particles have been jected upon the backing after a preliminary tation in the presence of the electric field, ce not only must such particles be floated in er to acquire a charge, but a separate project- means such as a blower has been considered essary.

s stated, the present invention utilizes a sin- step to propel and efficiently control the posi- s of the particles upon the backing. In other ds, reliance is solely placed upon the use of the trical force.

y reason of the invention, there is produced a uniform dispersion of the particles to form vel and continuous sand distribution upon carrier presenting a maximum number of ing points, (b) an orientation of the parti- such that the longest axes and sharpest edges positioned to produce maximum cutting ef- and (c) a stratification or classification reby the coarser fractions or particles are osed in the top plane where they can produce aximum abrading effect.

further object of the invention is to pro- an abrasive article of a flexible character, as sand paper, wherein the particles are elled first substantially laterally only under rol of an electrostatic field and then down- dly under control of the electrostatic field. retofore with various methods, the abrasive icles have been applied downwardly without control to the top surface of the adhesively d backing or carrier, and this has required an amount of abrasive in excess of what is ired to form a satisfactory coating, be fed he carrier and this excess subsequently re- d. When this excess of abrasive particles ed, the efficiency of the abrasive coating pro- d is reduced because the excess abrasive par- are afforded an opportunity to position selves or be accommodated in the voids be- n the permanently secured particles which have these two effects: (a) where fine or small sized excess particles fill up the voids between the permanently secured particles, then the necessary clearance between the cutting edges is reduced which has the final effect of reducing the cutting capacity of the coating and promoting rapid "filling" or "loading" with attendant burning and short life. In a measure it has the same effect as reducing the size of cutting particles since a smaller fraction of their total effective edges will now come into use; (b) where nominal size or over-grade excess particles become secured in the voids between the permanently secured particles there is produced in effect a superimposed layer of poorly secured particles since only a corner or edge of the larger grains can imbed itself between the permanently secured particles leaving the major portion of the grain in question to extend above the true abrading surface. This superimposed or secondary coating is objectionable because (1) it is a waste of grain; (2) it requires more sizing glue in the secondary step of sandpaper manufacture in order to hold on this superimposed coating with the result that the majority of the real abrasive surface is oversized, that is, overglued which greatly decreases its abrading efficiency; (3) in the finished article, these top particles above the level of the vast majority of particles on the true abrasive surface, are in themselves insufficient in number to really accomplish any removal of stock but in bringing sufficient pressure on the coating to cause the article being sanded to engage the real abrasive level, the higher or superimposed particles are either broken off or if sufficiently well imbedded, remain on the coating to scratch and injure the finish of the piece being sanded.

In the usual method of coating in which an excess of abrasive is employed, a means is positively provided which insures the creation of the superimposed coating while in the applicant's method, a positive control is provided to prevent the excess particles from filling up the voids between the permanently secured particles.

The invention is applicable for the manufacture of both "open coated," and "closed coated" sand paper, and is particularly useful where the sand particles are not of exactly uniform size and shape.

In the drawing the figure is a diagrammatic view of the invention.

The numeral 10 indicates a hopper in which the sand or other abrasive particles will be disposed. The hopper is provided with an upturned mouth. The backing or carrier 14 may consist of paper,

cloth, or a lamina of these two materials, and in fact any flexible backing as now used in the art. The backing is fed from a roll over suitable guide rollers to an adhesive applying device which will apply to the surface of the web a coating of adhesive 18.

The abrasive particles which are fed from the hopper are those customarily employed and constitute a mixture of "over grade," "below grade," and "control grade," in which the "control grade" predominates.

It will be observed that reliance is only had upon the electrical field as the means for propelling the abrasive particles to the backing and controlling their position upon the surface thereof.

No recourse is had to any accelerating means such as a blower nor are the particles preliminarily agitated in the field before they are propelled. As heretofore stated, where the particles are preliminarily floated or agitated in the field, it has been found essential that some additional positive projection means such as air be employed which I find prevents any control of the dispersion and destroys any possibility of orientation or stratification of the particles upon the adhesive surface of the backing.

In the drawing, I have illustrated the hopper 10 as being provided with an upturned mouth 11 and the abrasive particles are attracted therefrom laterally in one direction i. e., substantially laterally only to the field of the electrode 17, whereupon they are directed downwardly by reason of the field created between the electrode 17 and terminal 18, which is disposed below the web, and the electrode 17 as shown.

In this construction, as with that illustrated in Figure 1, the particles are propelled to the backing, oriented and stratified thereon solely by means of the electrical field of the oppositely polarized terminals 17 and 18.

The electrode 17 which is preferably negatively charged from a source of high potential, may take the form of an elongated bar or cylinder extending substantially across the transverse dimension of the web so that the entire surface of the web will be coated with the abrasive particles. Referring particularly to Figure 2, the electrode 17 will preferably be fixed but this electrode may be rotated, if desired.

I may transpose the method and construction in such manner that the movement of the particles to the web will be in a horizontal direction or in planes at an angle to both the vertical and horizontal without departing from the spirit of the invention.

No change is necessary other than that of transposing the web 14 to assume a vertical position in proximity to the roller 17, which, in the lateral propulsion, can be continuously rotated if desired.

It will, therefore, be seen that I have completely eliminated the necessity for preliminarily floating or agitating the particles in an electric field as well as the necessity for providing some positive means such as a blower for projecting such electrically charged particles upon the adhesive surface of a backing. Moreover, by propelling and controlling the positions of the particles upon the carrier in a single step as described, the control of the abrasive coating is positively assured.

The value of an effective control will be appreciated since reliance is had only upon a single factor, namely the electrical field, the strength of which may be varied, as occasion arises, and likewise, the spacing of the electrode 17 from the web may be changed to suit conditions as well as the strength of the field. By eliminating the necessity for a preliminary floating or agitation of the particles, or of using some additional positive projecting means, the control obtained is not interfered with in the slightest and the particles are attracted to the web 14 and their positions controlled thereon by reason of the single and complete effect of the electrical field, the intensity of which may be controlled and varied.

A further and important feature of the invention resides in the fact that the abrasive particles may be fed continuously to the electrostatic field, by means of the charged bar or conveyor 17.

The invention, it will be observed, assures a complete control of the disposition of the particles upon the web and enables the production of a sand paper which possesses (a) a level and uniform distribution of the sand particles, (b) an oriented disposition wherein the longest axes and sharpest edges of the particles are arranged to produce maximum cutting effect, and (c) a stratification or classification whereby the coarser particles or fractions of the abrasive mixture are positioned in the top plane of the completed article to exert the optimum abrading effect.

The construction and method illustrated possesses the very valuable advantage in that material is conserved and that an abrasive coating is produced which has a level top surface with all cutting points in the same plane and no undesirable superimposed particles. This feature is of particular importance since it is to be observed that by attracting the particles upwardly, there is avoided any tendency of a secondary surface to be built up over the permanently secured abrasive coating.

The invention achieves a final coated product having a maximum coating efficiency wherein the control of the particles and their propulsion to the carrier and disposition thereon is accomplished solely by the electrical means.

I claim:

1. An apparatus of the class described comprising a hopper for abrasive grit having an upwardly opening mouth, a negatively charged rotatable electrode disposed in such proximity to said mouth that grit is attracted laterally in one direction, means for moving a strip of backing material horizontally longitudinally beneath said mouth and electrode, means for applying an adhesive coat thereto and presenting the same upwardly, and a terminal immediately below said first electrode and said mouth and cooperating with the electrode for creating a field and directing the laterally projected grit downwardly into contact with the moving adhesive face of said strip.

2. An apparatus of the class described, comprising a delivering means for abrasive grain, a charged electrode disposed in such proximity to said grain-delivering means that grit is attracted first substantially laterally only therefrom to said electrode, means for moving a strip of backing material horizontally longitudinally beneath said grain-delivering means and said electrode, means for applying an adhesive coat thereto and presenting the same upwardly, and a terminal immediately below said first electrode and cooperating with the said electrode to create a field and then direct the laterally projected

[fol. 568]

grit downwardly into contact with the moving adhesive face of said strip.

1. A process of coating abrasive grits in oriented relationship onto an adhesively coated backing, comprising delivering grits from a grit storage means to an electrostatic field, passing an adhesively coated backing through an electrostatic field, first directing said grit substantially laterally only by means of the electrostatic field and then directing said grit along a vertical path by means of the electrostatic field to embed the grits into an adhesive coating superimposed upon the reinforcing backing, moving said coated backing from the electrostatic field and drying the adhesive.

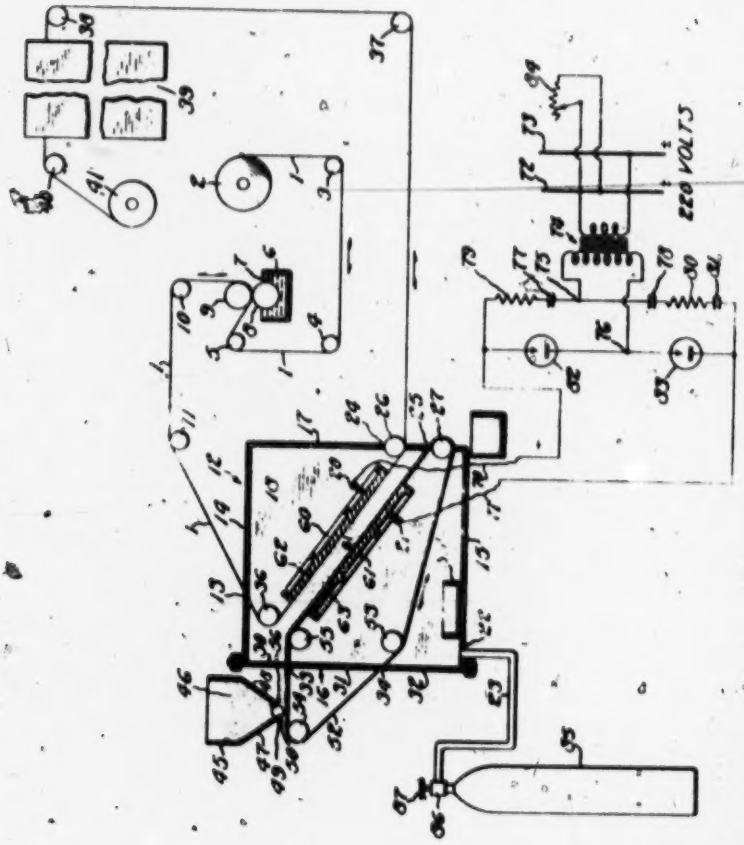
ELMER C. SCHACHT.

[fol. 569]

April 14, 1942. J. O. AMSTUZ 2,279,361

ELECTROSTATIC COATING PROCESS

Filed Feb. 19, 1938



Inventor
JOHN O. AMSTUZ

By

[fol. 570]

Patented Apr. 14, 1942

2,279,361

UNITED STATES PATENT OFFICE

2,279,361

ELECTROSTATIC COATING PROCESS

John O. Amstutz, Troy, N. Y., assignor to Behr-Manning Corporation, Troy, N. Y., a corporation of Massachusetts

Application February 19, 1938, Serial No. 191,472

5 Claims. (Cl. 91—68)

The invention relates to an electrostatic coating process, and with regard to its more specific features to the manufacture of abrasive paper and cloth.

One object of the invention is to provide a process whereby the electrostatic coating of sheet material may be speeded up. Another object of the invention is to provide an improved method of electrostatic coating by means of which abrasive particles in the larger sizes may be more effectively handled. Another object of this invention is to provide an improved method of electrostatic coating permitting the manufacture of abrasive paper and cloth using larger and heavier abrasive particles than heretofore. Another object of the invention is to accelerate the production of sandpaper of the oriented abrasive particle type. Another object of the invention is to provide an electro-coating method and apparatus permitting the use of smaller electrodes.

Another object of the invention is to reduce the possibilities of short circuits or arcing over between the electrodes, especially when the field stress between the electrodes is close to the breakdown value. Another object of the invention is to reduce the possibility of short circuit between the electrodes when binders are used which are inflammable or are apt to cause explosive mixtures or when binders are used which have low flash points or when temperatures are used which cause rapid evaporation of inflammable binders. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing in which is shown one of various possible embodiments of the mechanical features of this invention, the single figure is a diagrammatic representation of electrostatic coating apparatus constructed according to the invention and by means of which the process may be carried out.

The invention is equally applicable to the coating of cloth with abrasive or other comminuted material and also paper with abrasive or other comminuted material, for the production of abrasive cloth and abrasive paper, respectively, and in fact may be applied to the coating of any sheet material and even material which is not flexible, although it has special features of advantage when applied to the coating of flexible sheet material. It may be used for the application of comminuted material other than abrasive material to a surface, such as flock or piled surface products as used in the garment and shoe and textile industry. However, it will be more particularly described in connection with the manufacture of sheet abrasive material, of which abrasive coated paper, still familiarly referred to as "sandpaper," will be used as an illustrative example.

Referring now to the drawing, I provide a quantity of paper 1 initially in the form of a roll 2. The paper 1 is directed around a roller 3 and then around a roller 4 and up to a roller 5. I provide a glue trough 6 which may be suitably heated and in which is glue 7 or any other suitable adhesive for the manufacture of sandpaper or abrasive cloth. In the glue trough 6 and immersed in the glue 7 is a roller 8 above which is a roller 9. The paper 1 passes between the rollers 8 and 9 and then up to a roller 10. One or more of the rollers 3, 4, 5, 8, 9 and 10 are positively driven at a given peripheral velocity in order to feed the paper, this mechanism not being shown as it is well understood.

From the roller 10 the paper 1, now having a coating of glue on the upper side thereof, passes over a roller 11 and into a chamber 12. The paper 1 passes through a long slot 13 which is just wide enough to take the paper without contact between the paper or the glue thereon and the upper wall 14 of the chamber 12. The chamber 12 may take many different forms but as shown it is substantially a box-like structure, being a rectangular parallelopiped in shape and having the top wall 14 referred to, a bottom 15, back and front walls 16 and 17, a side wall 18, and an opposite similar side wall, not shown. The wall 18 and the opposite wall may be substantially imperforate excepting that insulating sleeves 20 and 21 may be provided for the introduction of electric potential, as hereinafter more particularly pointed out. The bottom 15 is preferably imperforate excepting for an opening 22 to receive a pipe 23. The front wall 17 may be imperforate excepting for openings 24 and 25 in which are mounted rollers 26 and 27 by means of any suitable journals, not shown. Preferably the back wall 16 is made in three detachable sections 30, 31 and 32 suitably fastened to the other parts of the chamber 12, in order that ready access may be gained to the inside of the chamber and so that the apparatus may be readily as-

sembled. This construction leaves slots 33 and 34 in the back wall 16 which are preferably narrow.

The paper 1 passes through the slot 13 and then around a roller 36 and through the chamber 12, passing around the roller 26, out of the chamber 12 and to a roller 37, then up and over a roller 38 to a drying chamber 39, thence over a roller 40 to the winding take-up roller 41. Abrasive is applied in the chamber 12.

The take-up roller 41 is driven at a varying angular velocity to wind the finished paper into the roll thereof 42 which increases in diameter, and one or more of the rollers 26, 36, 37, 38 and 40 may be positively driven, if desired.

I provide an abrasive hopper 45 supplied with suitable abrasive 46 therein. For the manufacture of sandpaper and abrasive cloth, I may use any suitable abrasive, such as silicon carbide, alumina, either fused alumina or any of the natural forms such as emery and corundum, also garnet and silica or sand. The bottom of the hopper 45 has inclined side walls 47 and 48 in between which is a bottom opening 49 with a delivery roller 50 which fits close to the wall 47 on the back side and has a somewhat larger opening on the front side, the roller 50 being positively rotated, for example in a clockwise direction, to deliver abrasive material at a fairly constant rate to a traveling belt 52. The traveling belt 52 is preferably a few inches wider than the paper 1 and it travels through the chamber 12 and outside thereof over and around the roller 27 and also rollers 53, 54 and 55 which may be located substantially as shown, the belt 52 passing through the slot 33 into the chamber 12 and through the slot 34 out of the chamber 12 to get the abrasive material which is deposited at 56. It will be seen that the belt 52 for a substantial distance runs parallel to the paper 1. Roll 27 is connected to a variable speed motor and acts as a driving roll for the belt. The belt speed can thereby be increased or decreased in order to feed more or less grain into the chamber 12 in order to control the sand weight.

I provide suitable electrodes which may be in the form of metal plates 60 and 61, for example made out of aluminum in order that they be not excessively heavy. These plates 60 and 61 may also have the rib-like construction shown, likewise for lightness, but preferably they have perfectly plane surfaces 62 and 63 which are parallel to each other and face each other. The paper 1 and the belt 52 pass between these surfaces 62 and 63, as shown. A conductor 70 passes through the insulating sleeve 20 and is connected to the electrode 60. A conductor 71 passes through the insulating sleeve 21 and is connected to the electrode 61.

I provide a source of electric current in alternating form, for example 220 volts at 60 cycles, in main line conductors 72 and 73. The line 72 and 73 is connected as shown to the primary of a transformer 74, the secondary of which is connected to terminals 75 and 76. Terminal 75 is connected to plates of condensers 77 and 78. The other plate of condenser 77 is connected to the conductor 70 through a resistance 79. The other plate of condenser 78 is connected to a resistance 80 which is connected to one plate of a condenser 81, the other plate of which is connected to the conductor 71. Two rectifiers 82 and 83 are connected in shunt across the conductors 70, 71 and to the terminal 76 as shown. The potential difference or coating voltage at the terminals 70 and 71 ranges from about 5,000 to 70,000 volts. This voltage range is obtained by the insertion of a voltage regulator 84 into the 220 volt side of the transformer 74. This may be a rheostat, as shown.

The rectifier set as shown in the drawing supplies a unidirectional current to the electrocoating unit. This kenotron rectifier can be replaced by a thyratron converter set which supplies the electrocoating unit with alternating current, pulsating direct current or any desired form of current of definitely controlled characteristics.

As the conveyor belt 52 carries the abrasive over the electrode 61 which is preferably in contact with the belt 52, the abrasive receives a charge and, attracted by the electrode 60, and repelled by the electrode 61, it jumps the gap between the belt and the paper and becomes embedded in the glue or other adhesive on the paper. By reason of the electrostatic field with the abrasive particles having like charges of electricity, the abrasive material is evenly and equally spaced and, furthermore, is oriented so that the long axis of each particle is normal to the paper upon which it is deposited.

Electro-coating, as previously practiced, has been somewhat restricted due to the fact that air ionizes in a field of the intensity of about 30,000 volts per centimeter. The field intensity varies with the temperature of the barometric pressure. A practical formula for calculating the intensity at which air reaches the break-down value due to ionization is believed to be as follows. The formula is only accurate for flat electrodes and a spacing or sparking distance greater than ½".

$$H = 81\sqrt{2} \times \frac{b}{273+t}$$

H = maximum field intensity in kv./cm.
b = barometric pressure in centimeters.
t = temperature in degrees centigrade.

Since the force exerted in abrasive particles increases in proportion to the square of the field intensity, it is important to increase H as much as possible. Under substantially sea level conditions and room temperatures, the maximum value for air is around 30,000 volts per centimeter, as above stated. With greater field intensities the air is ionized and becomes a conductor, under which conditions the field intensity drops to practically zero.

The rate of production of sandpaper or abrasive cloth with a given apparatus is substantially a straight-line function of the speed of the material 1 through the apparatus. Therefore, it is desirable to achieve as high a speed as possible, other things being equal. For a given grade of sandpaper or abrasive cloth, there are particular specifications as to the amount of abrasive material to the square inch which have to be met as nearly as practicable. There are practical limits to the shortness of the gap 64 between the paper 1 and the belt 52 owing to the chance of actual contact of the glue with the belt which would interfere with the beneficial results achieved by the use of the electrostatic field involving equal spacing of the grains and orientation, and the fact that the abrasive particle should be allowed to jump a substantial distance in order to give it room enough and time enough in which to orient itself, as above specified, and also to allow several particles which may be bunched together to separate and space themselves properly. For all these reasons, in actual practice in the manufacture of sandpaper, it has

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been found highly desirable and important to have the gap 91 at least ¾" wide, and the closest gap which has heretofore been found thoroughly practicable has been of the order of ½", whereas it is considered desirable in most cases to have a gap at least 1" wide. Furthermore, there are practical limitations on the length of the electrodes 90 and 91 in the direction of movement of the paper involving the use of a great deal of power if the electrodes have too large an area including greater opportunity for dielectric loss and because of space limitations and the desirability of applying the abrasive within a certain time limit following the coating of the paper with glue. As a practical matter, it has been found that with a gap of 1", the electrodes should be no longer than 6', that is to say the distance between the upper and lower rollers should preferably be not substantially greater than eight feet.

From the foregoing it will be appreciated that it has been desired to create a field intensity as great as possible but, as above explained, there have been definite limitations to the field intensity which could be employed and it should be noted that because temperature, humidity and barometric pressure vary, some margin has been heretofore provided in actual practice.

Referring to the attached drawing, I provide in the chamber 12 an atmosphere which ionizes at a substantially greater field intensity than air. There are many gases which have a greater break-down value than air. Many of them are dangerous, corrosive, or explosive. Others constitute a fire hazard. Among all the gases known for maximum stress higher than air, there are a number which are quite harmless. These gases may be used for our purpose of increasing the field intensity H between the coating electrodes. Among these gases are, for example, nitrogen (N_2), or nitrogen oxide (N_2O). On the other hand, I may use vapors of certain liquids in atmospheric air, for example vapors of methyl chloride (CH_3Cl) or carbon tetrachloride (CCl_4). Referring again to the drawing, I may provide a tank 96 containing the desired gas, fitted with the usual valve 96 connected to the pipe 23. By turning the handle 97 of the valve 96, gas is admitted to the chamber 12 in a steady flow so long as it lasts. Although there are various slots 13, 24, 25, 26 and 34 out of which the gas may flow, the direction of flow is substantially outward and the gas in the chamber 12 is substantially the gas provided in the bottle 96. I prefer to use such gases as nitrogen and nitrous oxide as they have little effect upon human beings in diluted quantities. I may provide suitable exhaust apparatus to convey away the gases as they escape. Satisfactory results are achieved even though the gas in the chamber 12 is not 100% pure nitrogen, nitrous oxide, etc., but contains a substantial quantity of air.

Figures for ionization of the gases mentioned, assuming 90% pure gas, 10% air, are substantially as follows:

$$\text{Nitrogen: } H = 132\frac{b}{273+t}$$

$$\text{Nitrous oxide: } H = 182\frac{b}{273+t}$$

or for b=76 cm. & t=20° C.
H max. for N_2=34.8 kv./cm.
H max. for N_2O=39.0 kv./cm.

As will be observed from the foregoing examples, it is possible with my invention to use a higher field intensity than has heretofore been possible. The field intensity is measured in volts per centimeter and with my invention it is, therefore, possible to operate with a higher voltage per centimeter or per inch of electrode gap or spacing than has heretofore been possible. Stated in another way, this means that, with a given electrode spacing, it is feasible to use a higher voltage across the electrodes by employing my invention than has heretofore been possible. Therefore, a stronger force may be exerted upon the particles being applied in the gaseous media that I provide than has heretofore been possible with air. I am, therefore, able to coat a backing sheet with the usual particles of various kinds with greater speed, and I am also able to coat with heavy particles which could not heretofore be successfully deposited by the electrostatic method. The essence of my process is, therefore, the provision of an atmosphere which ionizes at a higher potential than air, combined, preferably, with higher field intensities than have heretofore been practical with air.

Further referring to the drawing, I may provide instead of the bottle 96 or even in conjunction therewith a pan 98' containing any one of the liquids mentioned or suitable equivalents, and under normal conditions of temperature and humidity there will be produced in the chamber 12 a fair concentration of vapors from the liquid. Naturally the results are more variable with this procedure but in practice I am enabled to achieve, using the various liquids mentioned, field intensity values of 36.2 kv./cm. and 36.8 kv./cm., respectively, for methyl chloride and carbon tetrachloride in the formula—

$$H = a\frac{b}{273+t}$$

a for CH_3Cl=140
a for CCl_4=230

the above being the given value for a in respective cases.

In the use of the apparatus and method of the invention, manufacture of sandpaper may be speeded up as much as 30%. Furthermore, larger grit sizes may be used up to 2½ grit size. Furthermore, better results and better production can be achieved using the present apparatus and method because other factors including the size of the gap 91 and the length of the electrode 90 may readily be kept within safe limits, yet achieving a high rate of production.

Furthermore, gases or vapors may be used which will reduce fire hazards or prevent spark discharges or the sustaining of an electric arc between electrodes.

I mentioned in the above disclosure only a few gases or vapors as examples. There are many more which can be used and some are listed below:

Trichlorofluoromethane	CCl_3F
Dichlorotetrafluoroethane	$C_2Cl_2F_4$
Trichlorotrifluoroethane	$C_2Cl_3F_3$
Dichlorodifluoromethane	CCl_2F_2
Trichloromethane	$CHCl_3$
Trichloro acetyl chloride	CCl_3COCl
Dichlorofluoromethane	$CHCl_2F$
Dichloromethane	CH_2Cl_2
Chlorofluoromethane	CH_2ClF
Ethylene chlorohydrine	CH_2ClCH_2OH

Very effective are mixtures of nitrogen with some vapors or gases, for example, mixtures of

carbon tetrachloride, and nitrogen or dichlorofluoromethane and nitrogen.

It will thus be seen that there has been provided by this invention a method and apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. The method of coating with comminuted material such as flock, which comprises providing a gaseous atmosphere which ionizes at a higher electrostatic field intensity than air, creating an electrostatic field in said atmosphere of an intensity which would create a danger of ionizing air but lower than that which ionizes the atmosphere, locating the article to be coated in said field and introducing the comminuted material into the field adjacent the article.

2. The method of coating with comminuted material which comprises creating an electrostatic field, locating the article to be coated in the electrostatic field, feeding the comminuted material to the electrostatic field, providing an atmosphere in the electrostatic field which ionizes at a higher field intensity than air, and raising the intensity of the field to an intensity that would create a danger of arc-over or ionization in air, but lower than that which creates such a danger in said atmosphere.

3. The method of coating sheet material which comprises coating the sheet material with adhesive on one side thereof, providing an atmosphere which ionizes at a higher electrostatic field intensity than air, creating an electrostatic field in said atmosphere of an intensity at least as high as one that would create practical dangers of arc-over in an atmosphere of air but lower than one that would create practical dangers of ionizing said atmosphere, feeding the sheet material through said field and feeding comminuted material to the electrostatic field, the coated side of the sheet material being disposed in proximity to the comminuted material as it is fed into the field.

4. In the production of piled surfaces by passing pile forming material adjacent an adhesive surface foundation material positioned in an electric field, the steps which comprise introducing into the field an atmosphere conditioning gas which ionizes at a higher field intensity than air, and raising the intensity of the field above an intensity that would create dangers of arc-over or ionization in air but lower than that which would create such dangers in the atmosphere as conditioned by said gas.

5 The method of coating sheet material with comminuted material which comprises introducing into a substantially enclosed space, a gas or vapor having the characteristic of ionizing at a higher electrostatic field intensity than air and thereby creating in said space an atmosphere which ionizes at a higher field intensity than air, creating an electrostatic field in said atmosphere of an intensity that would create a danger of ionizing air but lower than that which ionizes said atmosphere, conducting adhesively coated sheet material through said electrostatic field, introducing comminuted material into the field adjacent the adhesively coated surface of the sheet material, and projecting the comminuted material onto the adhesively coated surface of the sheet material by an electrostatic force of greater intensity than would be possible in an atmosphere of air alone.

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[fol. 574]

June 30, 1942. J. S. SMYSER 2,287,837

METHOD AND APPARATUS FOR APPLYING COATING MATERIALS

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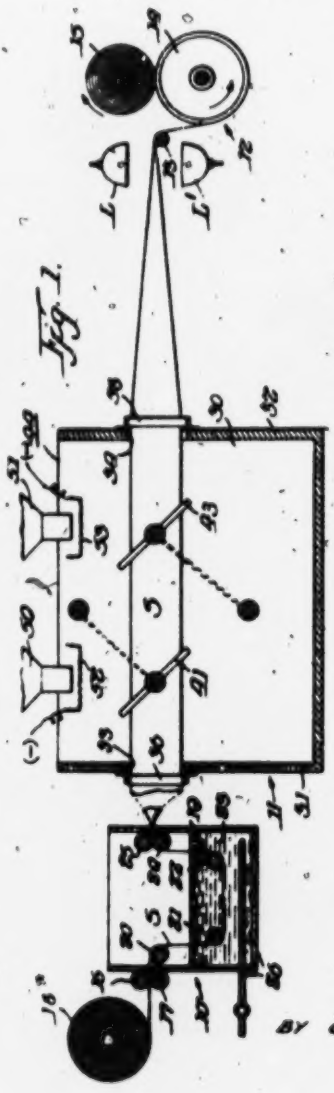

Fig. 1.

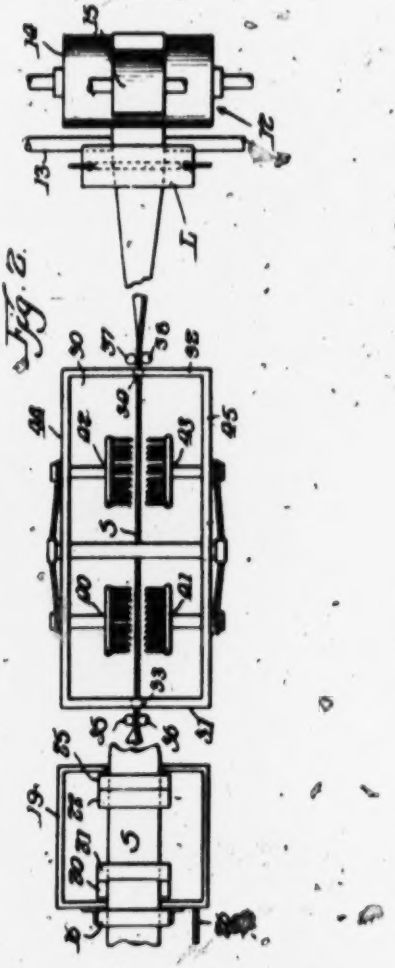

Fig. 2.

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METHOD AND APPARATUS FOR APPLYING COATING MATERIALS

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Fig. 3

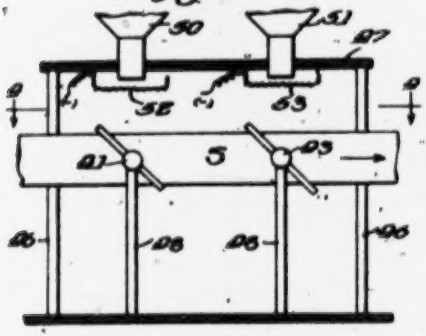


Fig. 5

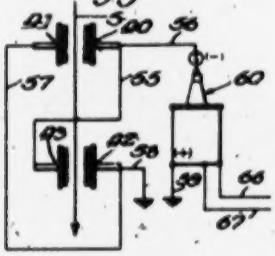


Fig. 5a

Fig. 4

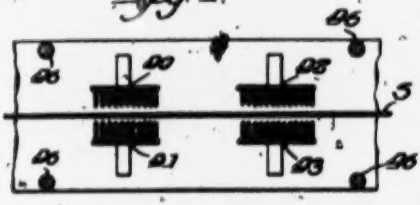


Fig. 6

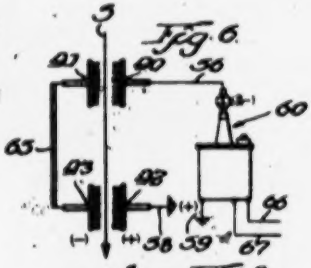


Fig. 7

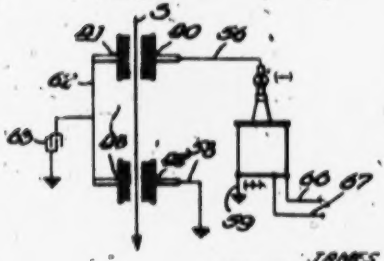
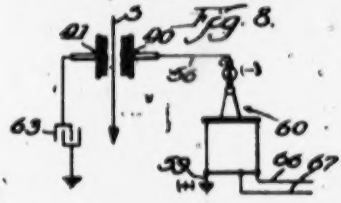


Fig. 8



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METHOD AND APPARATUS FOR APPLYING COATING MATERIALS

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Fig. 9.

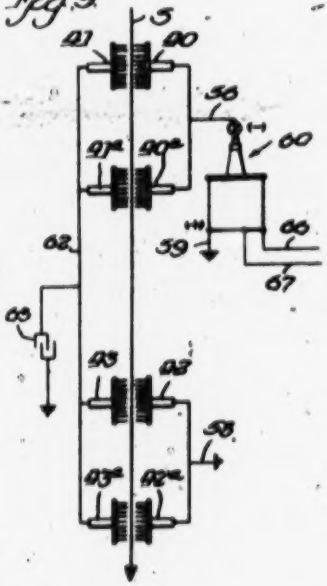


Fig. 11.

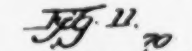


Fig. 12.

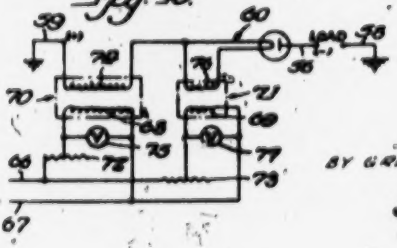
Fig. 13.

Fig. 15.

Fig. 14.

Fig. 16.

Fig. 10.



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METHOD AND APPARATUS FOR APPLYING COATING MATERIALS

Original Filed April 25, 1934 4 Sheets-Sheet 4

Fig 17.

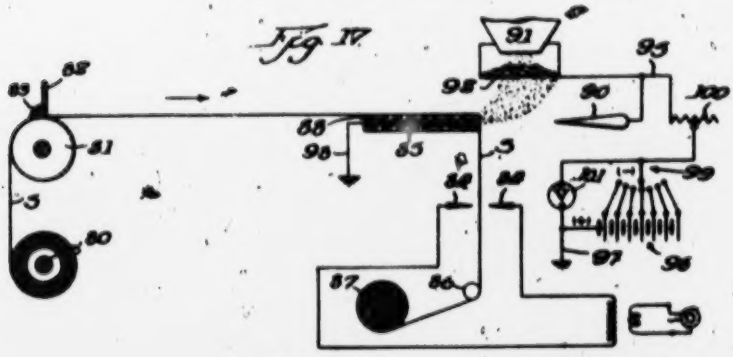


Fig 18.

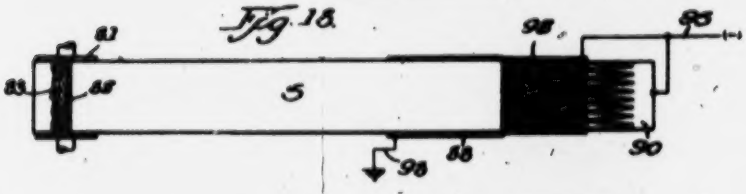


Fig 19.

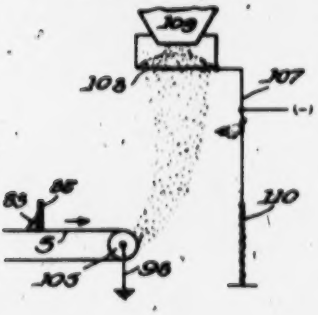
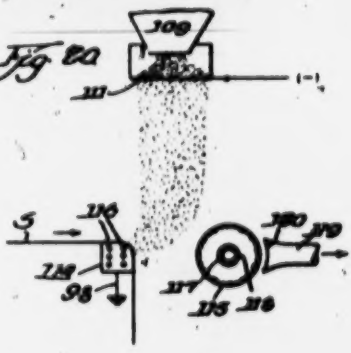


Fig 20.



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Patented June 30, 1942 2,287,837

UNITED STATES PATENT OFFICE

2,287,837

METHOD AND APPARATUS FOR APPLYING COATING MATERIALS

James S. Smyser, deceased, late of Quincy, Mass., by Granite Trust Company, executor, Quincy, Mass., assignor to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware

Substituted for abandoned application Serial No. 723,598, April 25, 1934. This application January 22, 1941, Serial No. 375,455

6 Claims. (Cl. 117—17)

This invention relates to a method of and apparatus for applying particles and finely divided materials, such, for example, as flock, linters, and the like fibrous material, abrasive particles, etc., to one or more surfaces of a base member, such as a piece of sheet material; to provide means for controlling the manner and rate of application or disposition of the particles so as to obtain a uniformly coated product having predetermined characteristics; and to provide means whereby unlimited lengths of sheet material may be coated efficiently and progressively, on either or both sides, more quickly, densely, uniformly and cheaply than by any apparatus and/or method heretofore used.

Other objects of the invention are to provide a strong and flexible product having a dense, homogeneous, velvet finish simulating the appearance of either suede or a pile fabric; and to provide a finish of any desired density wherein the major portion of the fibers are disposed at substantially the same angle relative to the surface of the base sheet with their ends firmly embedded in an adhesive coating carried thereby.

Further objects relate to the construction of the apparatus and to the mode of operation of the method, and will be apparent from a consideration of the following description and accompanying drawings which exemplify different embodiments of the invention in its apparatus, product and process aspects.

In accordance with the present invention the surface (or surfaces) of the base member, or article to be coated is first rendered adhesive, as for example by the application of a suitable cementitious material, such as rubber cement, wax, paraffin, glue, or the like adhesive. When thus coated the base member is passed through an electrostatic field set up between one or more pairs of oppositely charged electrodes, and during its passage through the electrostatic field the particles to be applied are carried in a uniformly dispersed formation into the field either by gravity, a current of air, or in any other suitable manner.

Preferably the particles being conveyed to the field are charged in any suitable manner with the same charge as that of the electrode projecting them against the base member, and to this end they may be passed through a metallic screen or the like member which is connected in the circuit of the projecting electrode. When thus charged, the particles, upon entering the electrostatic field are projected against the adhesive surface of the base member more uniformly and efficiently, and with much greater force than would otherwise be possible. Furthermore, the individual particles are more effectively aligned in the direction of the lines of force of the electrostatic field and, due to the increased force with which they are projected against the surface of the base member, are more deeply and firmly embedded in the adhesive surface of the base member. Moreover, migration of the charged particles toward the adjacent or projecting electrode is greatly minimized, if not substantially eliminated, and consequently considerable waste is eliminated and the efficiency of the method and apparatus is appreciably increased.

The construction and arrangement of the electrodes is such as to provide an electrostatic field of uniform flux density which extends across the path of the surface of the article to be coated and at an angle to its path of travel. The position of the individual particles relative to the surface of the base member may be controlled and /or varied by adjusting the relative position of the electrodes so as to obtain the desired direction of the lines of force of the electrostatic field relative to the surface of the base member. To this end one or both of the electrodes may be adjustably mounted so that their position relative to each other may be varied.

The electrostatic field may be produced by a suitable source of potential such as a Kenotron or the like alternating current rectifier, a static machine, mechanical rectifier, or any other source which may be susceptible to control. The potential impressed upon or across the electrodes may vary within wide ranges, depending upon the character of the material to be deposited, the desired rate of deposition, etc., and the usual types of control instrumentalities may be employed to provide an electrostatic field of the desired characteristics.

The rate of deposition or application may be so controlled as to produce a coated product of any desired density by varying the quantity of particles supplied, the rate of travel of the base member through the field, and/or the electrical characteristics of the field, i. e., the flux density,

voltage across the electrodes, etc. To this end suitable means may be employed to control the rate of delivery of the particles and the rate of travel of the base member, and appropriate devices such as rheostats and various types of impedances, together with the usual indicators (ammeters, voltmeters, etc.), may be connected in the electrical circuits or circuit to provide for the adjustment necessary to obtain an electrostatic field suitable for the application or deposition of the particular type of material to be applied.

Where high potentials are employed or where the adhesive surface of the sheet material or base member contains an inflammable solvent, it is necessary to prevent "sparking" and suitable means may be employed to discharge or neutralize the static charge on the surface of the coated sheet before winding. To this end an ultra-violet light may be employed or, if desired, the coated sheet may be passed between electrodes connected to a high potential alternating current circuit, either of which is effective to discharge or neutralize any static charge carried by the coated sheet.

In the drawings:

Fig. 1 is a diagrammatic side elevation, in section, showing one embodiment of my apparatus;

Fig. 2 is a diagrammatic plan view of the apparatus shown in Fig. 1, the means for feeding the particles to be applied being omitted;

Fig. 3 is a diagrammatic side elevation, in section, showing a modified form of apparatus;

Fig. 4 is a section on line 4—4 of Fig. 3;

Fig. 5 is a schematic diagram illustrating one arrangement of the electrical connections;

Fig. 6 is a graphic representation of a pulsating current used in connection with certain forms of the apparatus herein shown;

Figs. 7 to 9, inclusive, are schematic diagrams illustrating other arrangements of the electrical connections;

Fig. 10 is a schematic diagram showing the electrical connections of a Kenotron transformer;

Fig. 11 is a fragmentary7 section showing a piece of fabric before the application of an adhesive coating;

Fig. 12 is a fragmentary section showing the fabric after the application of the adhesive coating;

Figs. 13 to 16, inclusive, are enlarged fragmentary7 sections showing different specimens of sheet material after being coated in accordance with the present invention;

Fig. 17 is a horizontal view with parts shown in section of another modified form of apparatus;

Fig. 18 is a plan view of the apparatus shown in Fig. 17; and

Figs. 19 and 20 are horizontal views, with parts shown in section of further modified forms of apparatus.

The embodiment shown in Figs. 1 and 2 comprises a coating apparatus 10, a deposition apparatus designated by the numeral 11, and a winding mechanism 12. The coating apparatus may be of any type suitable for applying a coating of adhesive such as rubber cement, wax, glue, paraffin, or the like cementitious material to one or both surfaces of a base member or sheet material 8, and as here shown comprises a tank or trough 10 having guide rolls 16, 17, 20, 21 and 22 to conduct the sheet material through a fluid bath 23 of suitable adhesive, and squeeze rolls 24 and 25 to remove excess adhesive and distribute the coating uniformly over the surfaces of the sheet 8. The temperature and fluidity of the bath 23 may be controlled in any suitable manner as by steam coils 26. The winding apparatus 12 may be of any conventional form and is here shown as comprising a guide roll 18, a winding drum 14, and a reel 15, upon which the coated sheet material is wound. Suitable means (not shown) may be provided to regulate the speed of the winding drum 14 and thus control the rate of travel of the sheet material 8.

The deposition apparatus 11 comprises a box-like structure or housing preferably having upright or walls of suitable electrical non-conducting material which define the deposition zone or chamber 30, the top of which may be open as shown in Fig. 1. The end walls 31 and 32 are provided with vertically extending slots or openings 33 and 34, respectively, through which the sheet material 8 may be conducted into and out of the zone or chamber 30, and guide rolls 35, 36, 37 and 38 are provided to support the sheet 8 for movement along a predetermined path through the deposition zone or chamber 30.

Electrodes 40, 41, 42 and 43 are mounted in pairs, each electrode comprising an elongate metallic bar secured to a suitable support and having a series of pointed members or prongs secured thereto and arranged as shown in Fig. 2. The electrodes are arranged in pairs 40, 41 and 42, 43 and may be connected to any suitable source of potential as hereinafter described. The elements of each pair are disposed on opposite sides of the path of travel of the sheet 8 and are preferably inclined at an angle to its line of travel so as to provide an electrostatic field which extends diagonally across the path of movement of the sheet 8. The purpose of this inclined arrangement is to insure a more even coating when the communicated material is fed to the electrostatic field from the top.

Suitable means are provided to conduct the material to be deposited on the sheet 8 into the electrostatic fields set up between each pair of electrodes and to this end hoppers 50 and 51 may be arranged directly above electrodes 40, 41 and 42, 43, respectively. If it be desired to coat one side of the sheet 8 only, the hoppers may be arranged to discharge the coating material into a zone between the projecting electrode and surface of the sheet to which the material is to be applied. Where both sides of the sheet 8 are to be coated, the hoppers may be arranged to discharge the particles on both sides of the sheet 8, or, if desired, one hopper may be arranged to discharge the material on one side of the sheet and the other hopper on the opposite side, the particular arrangement depending upon the connections of the electrodes for the most effective results.

At some convenient location between the hoppers 50, 51 and the electrostatic fields, there may be provided means for imparting an electrostatic charge to the particles to be applied and to this end metallic screens 52 and 53, or the like, may be mounted beneath the discharge openings of the hoppers 50 and 51, as shown in Fig. 1, or, if desired, these screens may be integral with the hoppers. Each of the screens are connected to the negative electrode or to the negative terminal of a suitable source of potential so that the particles as they emerge from the screens have the same negative charge as that of the negative or projecting electrode. Suitable means (not shown) may be employed to control the rate of delivery of the particles from the hopper so that

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the density of the coating applied to the sheet material may be varied as desired.

The embodiment shown in Figs. 3 and 4 is a preferred form of deposition apparatus and includes all the essential elements of the apparatus shown in the previously described embodiment. In this embodiment the side and end walls of the deposition chamber have been dispensed with and uprights 46 are provided to support an insulating top plate 47 on which the hoppers 56 and 61 and the screens 62 and 63 are mounted. The electrodes 40, 41, 42 and 43 are supported on uprights 48 which are mounted on the base of the apparatus or they may be suspended from the top plate. Suitable means (not shown) may be provided to guide the sheet S between each pair of electrodes as in the previously described embodiment.

In Figs. 5 to 9, inclusive, are shown various ways in which the electrodes may be connected for use with a pulsating current (graphically represented in Fig. 5a) such as may be derived from a two-tube Kenotron rectifier, or a continuous (non-pulsating) current such as may be derived from a static machine, mechanical rectifier with a suitable condenser, a high voltage generator, or the like, the arrangement shown in Figs. 6 to 9 being particularly suitable for use with a pulsating current.

In the arrangement shown in Fig. 5, the electrodes 40 and 43 are connected to each other by a conductor 86 and by a conductor 90 to a suitable source of potential, here shown as a Kenotron rectifier designated generally by the numeral 89. The electrodes 41 and 42 are connected to each other by a conductor 87 and to the ground by a conductor 88. With this arrangement the conductors 86 and 90 are preferably connected to the negative terminal of the Kenotron 89 or other source of potential and its positive terminal may be grounded by means of conductor 88 or connected to the positive terminal of the source of potential, as desired. When thus connected the current flows from the Kenotron through a main circuit comprising the conductor 90, the ground and conductor 88, at which point the main circuit branches into two circuits, one of which comprises electrodes 42 and 43 and the conductor 86, the second branch circuit comprising the conductor 87 and electrodes 41 and 40. The conductor 86 connects the branch circuits to the negative terminal of the Kenotron and thus completes the main circuit from the Kenotron to the electrodes.

This arrangement is particularly suitable for use wher both sides of the sheet S are to be coated as it will be noted that the negative or projecting electrodes 40 and 43 are on opposite sides of the sheet S and the intensity of the electrostatic fields established between each pair of electrodes is always the same. When this arrangement is used in conjunction with the apparatus shown in Figs. 1 and 2, the screens 62 and 63 may be connected to the electrodes 40 and 43, respectively, so that the particles discharged into the electrostatic field are first given a negative charge. The hoppers 56 and 61 and the screens 62 and 63 are preferably positioned so that the charged particles are delivered into that portion of the electrostatic field between the projecting electrode and the adjacent surface of the sheet to be coated.

In the arrangement shown in Fig. 6 electrodes 40 and 42 are connected one to the negative terminal of the Kenotron and the other to the ground or to the positive terminal of the source of potential by conductors 86 and 88, respectively, and the electrodes 41 and 43 are connected to each other by a heavy metallic bar 85 which provides an appreciable capacitance in the circuit between the electrodes 41 and 43. These electrodes and the bar 85 constitute, in effect, a unit which acts as a condenser and which builds up its charge as the potential increases from zero to maximum and discharges through the electrodes 41 and 43 as the potential drops from maximum to zero (Fig. 5a). In place of the bar 85, the alternative arrangement shown in Fig. 7 may be used, in which case the electrodes 41 and 43 are connected to each other by a conductor 82 which is connected to one terminal of a condenser 83, the other terminal of the condenser being grounded. With either of these arrangements the flow of current through the circuit as the potential increases from zero to maximum is from electrode 42 to 43 and from electrode 41 to 40, the electrodes 41 and 43 being positively charged and electrodes 40 and 43 being negatively charged. When the potential reaches a maximum the electrodes 41 and 43 become fully charged so that when the potential drops from maximum to zero, there is a discharge from electrodes 41 and 43 through electrodes 40 and 42, respectively. Either of the arrangements shown in Figs. 5, 6 and 7 may be used with the apparatus shown in Figs. 1 to 4 in coating either or both sides of the sheet S.

The arrangement shown in Fig. 8 comprises a single pair of electrodes 40 and 41, the electrode 40 being connected to the Kenotron 89 by conductor 86, and the electrode 41 being connected to the ground or the conductor 90, as preferred, by a circuit which includes the condenser 83. This arrangement is particularly suitable where only one side of the sheet S is to be coated.

The arrangement shown in Fig. 9 is substantially the same as that shown in Fig. 7 except that instead of using two pairs of electrodes, four pairs, 40—40', 41—41', etc. arranged in tandem are employed. This arrangement is particularly suitable where a much denser coating of material is to be applied.

In Fig. 10 is shown a preferred form of electrical connections which affords an effective means of controlling the characteristics of the electrostatic field when an alternating current rectifier is used as a source of potential. The numerals 96 and 97 designate the alternating current power supply lines which are connected to the terminals of the primary windings 69 and 99 of a main transformer 70 and a filament transformer 71, respectively. Rheostats 72 and 73 are connected in the respective circuits so as to control their outputs. One terminal of the secondary winding 74 of the main transformer 70 is grounded by means of the conductor 98 (see also Figs. 5 to 9) and the other terminal is connected to the filament circuit of the rectifier or Kenotron 89, a voltmeter 76 being connected across the terminals of the primary winding 99. The filament circuit of the rectifier or Kenotron 89 is connected to the secondary 78 of the filament transformer and a voltmeter 77 may be connected across the primary 99 in the manner shown. The output terminal of the rectifier 89 is connected to the load by the conductor 90, as shown in Figs. 5 to 10. With this arrangement, the output of the rectifier may be accurately controlled by adjusting the rheostats 72 and 73 and thus the electrostatic fields set up between the elec-

trodes may be varied so as to attain the desired strength, density, etc.

In using the apparatus shown in Figs. 1 to 4 to carry out the process, the sheet material S, such as a piece of fabric 70 (Fig. 11), is drawn from the supply roll 15, through the bath 23 where a coating 71 (Fig. 12) of adhesive such as glue, paraffin, rubber cement, wax or the like is applied to both surfaces. While the adhesive coating is still tacky the sheet is guided between each pair of electrodes, as indicated in Figs. 1 to 10. The rheostats 72 and 73 are adjusted to produce the desired potential across the electrodes and thus establish an electrostatic field of the desired strength and intensity. After having made these adjustments the material to be applied is fed from the hoppers 30 and 31 at a predetermined rate and after passing through the screens 32 and 33 where the individual particles receive a negative charge, they are then carried by gravity into the electrostatic field. When material such as flock, linters and the like fibers, as well as the various forms of abrasive material such as carborundum, pumice, tripoli, etc., constitute the coating material being applied, the individual particles upon entering the electrostatic field, due to their elongate nature, become aligned in the direction of the electrostatic lines of force and are uniformly projected or bombarded against the adhesive surface of the sheet S so that their ends are deeply and firmly embedded in the adhesive coating at substantially the same angle and their projecting portions are disposed in substantial parallelism relative to each other. Due to the initial charge imparted to the particles, they tend to repel each other and become dispersed so that upon being projected against the adhesive surface of the sheet S the individual particles are spaced relatively to each other. As the individual particles align themselves with their major axes coinciding with the direction of the electrostatic lines of force, they may be applied to the sheet S so that their major axes are disposed at any desired angle relative to the surface of the sheet and consequently a greater number of particles per unit area may be applied to the sheet and with greater uniformity than is otherwise possible. When thus applied, their embedded ends are held in spaced relation to each other on the sheet S and by reason of capillary action and the removal of the film of air surrounding the particles the adhesive creeps up or rises along their sides forming a meniscus about the embedded ends of each individual particle.

After having received a coating of particles on one or both surfaces, sheet S is guided out of the deposition zone and passed between a pair of ultra-violet lights L and L' or other suitable means operative to discharge or neutralize the static charge carried by the coated surface without causing sparking. After removing the static charge on the sheet, it is then wound up on the reel 18. During both the coating and deposition operations the sheet S is held under slight tension by the "pull" of the winding drum and reel. The density of the coating may be varied, as desired, by varying either the rate of travel of the sheet S, the rate of delivery of the particles from the hoppers 30 and 31, or both, and the strength of the electrostatic field may be varied accordingly.

When applying fibrous material at a relatively low rate, a potential of the order of 15,000 to 20,000 volts may be used, although it is preferred to use potentials from 100,000 to 200,000 volts, particularly where heavier particles are being applied or where the rate of application is to be greatly increased, the particular voltage depending upon the character of the particles, the rate of travel of the sheet, and various other operating conditions.

In Figs. 17 to 20 are shown different modified forms of deposition apparatus particularly suitable for the application of flock, linters, asbestos fiber, wood pulp fibers, fine abrasives and the like materials, to an adhesive coated surface of a base member. In the embodiment shown in Figs. 17 and 18 the sheet material S is drawn from the supply roll 80 over a spreader roll 81 provided with a spreader blade 82 which is operative to distribute a fluid or plastic adhesive 83, such as rubber cement or the like, uniformly over the surface of the sheet S. After having received a coating of adhesive of suitable thickness, the sheet is drawn over or about a guide member which constitutes a part of the deposition apparatus. Thereafter the sheet is drawn downwardly between a pair of discharging electrodes 84, 84 connected to a suitable source of high potential operating current, then over a guide roll 85 and wound on a reel 87, as in the previously described embodiments.

The guide member preferably comprises a plate electrode 86 interposed between two sheets of electrical nonconducting material such as Bakelite, the upper sheet or layer 88 having a smooth surface and being provided with a rounded or beveled edge as shown in Fig. 17. The negative electrode 89 is disposed opposite the end of the electrode 86 and is arranged so as to establish a field whose lines of force intersect the path of travel of the sheet S at any desired angle. Preferably the length of each electrode is sufficient to provide an electrostatic field having a width corresponding to that of the sheet S.

A supply hopper 91 is disposed above the electrostatic field and is constructed and arranged to deliver the fibrous material onto a screen 92 or the like device interposed between the field and the hopper. The electrical connections are shown schematically in Fig. 17 wherein a conductor 95 connects the screen 92 and the electrode 89 to the negative terminal of a suitable source of potential designated by the numeral 96, the positive terminal being grounded by a conductor 97 or connected to the electrode 86, as desired. The electrode 86 may be grounded by a conductor 98 or otherwise connected to the conductor 97, and suitable means such as a controller 99 and rheostat 100 may be provided to control the potential and flow of current in the circuit. If desired, a voltmeter 101 may be connected in the circuit in the usual manner. The electrodes 84, 84 when connected as shown in Fig. 17, establish an alternating electrostatic field across the path of the coated sheet and are thus effective to discharge or neutralize any static charge carried by the sheet. The operation of the apparatus is substantially the same as that of the previously described embodiments, it being understood that the present arrangement is designed to coat only one surface of the sheet S at one time.

In the embodiment shown in Fig. 19, the granulitious material is applied to the sheet S in the same manner as in the embodiment shown in Figs. 17 and 18. In place of the guide member and plate electrode shown in Figs. 17 and 18, a roller electrode 105 is used. The roller electrode

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provides a guide roll about which the sheet 8 is drawn on its way to the winding drum or reel (not shown) and may be connected to the ground or otherwise, as in the previously described embodiments. The negative electrode 107 comprises a metallic screen member which is shaped to provide a substantially horizontal portion 108 through which the particles discharged from the hopper 109 may pass, and a depending portion 110 disposed opposite but parallel to the roller electrode 106. The supply hopper 109 is disposed above the horizontal portion 108 of the negative electrode so as to discharge the particles onto its horizontal portion. The negative electrode is connected to the negative terminal of the source of potential and the usual control devices may be provided as in the previously described embodiment.

The embodiment shown in Fig. 20 is somewhat similar to that shown in Figs. 17 and 19 but is particularly designed for use in applying particles to a sheet having an adhesive coating which comprises a thermoplastic cementitious material, such as wax, paraffin, etc., which must be maintained in a relatively fluid or tacky condition during the deposition operation in order that the ends of the particles may be firmly embedded therein. The apparatus embodies all the essential elements shown in Figs. 17 to 19 but in place of the electrodes shown therein, a metallic block 114 and rotor 115 are used. The block 114 constitutes the positive electrode and preferably comprises a metallic casting having a series of longitudinally extending ducts or channels 116 which may be connected to a steam or hot water supply (not shown). The outer walls of the block 114 which contact with the sheet material are smooth and the adjacent corner is preferably rounded or beveled to provide a suitable guiding surface over which the sheet 8 is drawn. The rotor 115 constitutes the negative or projecting electrode and preferably comprises a cylindrical screen or grating supported on a circular plate which is rotatably mounted on a stationary tubular shaft 117. The tubular shaft 117 is provided with a radially disposed axially extending slot co-extensive with the longitudinal extent of the screen and facing away from the electrode 114. A conduit 119 having an elongate, horizontally extending, flaring mouth or entrance 120 disposed in radial alignment with the slot 118, is disposed closely adjacent to the electrode 115, as shown, and may be connected to a suitable suction fan or the like (not shown). A supply hopper 109 and a charging screen 111 are provided as in the embodiment shown in Fig. 17 and similar electrical connections, controls and means for discharging the static charge from the coated sheet may be employed. During the deposition operation the electrode 115 is continuously rotated, compressed air being introduced into the shaft 117 and discharged through the slot 118, and the electrode 114 is maintained at a predetermined temperature by the flow of steam or hot water through the ducts 116. The force of the air striking against the screen or grating of the electrode 115 is sufficient to remove any accumulations of oriented fibrous material or other particles and carry them into the conduit 120, thus keeping the negative or projecting electrode relatively free of oriented material.

In Figs. 13 to 16, inclusive, are shown different types of coated sheet material produced in accordance with the present invention. The products shown in Figs. 13 and 14 each comprise a base member or backing sheet 121, such as a sheet of heavy paper, a layer 122 of glue or the like binder, and a coating of abrasive particles 123 which have their ends deeply embedded in the binder 122. It will be noted that the individual particles are more or less elongate in character and are disposed with their major axes substantially at right angles to the surface of the backing sheet, and that their free ends, being disposed in substantial parallelism relative to each other, present a most effective cutting or abrading surface.

The product shown in Fig. 15 comprises a backing sheet 126, such as a sheet of fabric, a layer 126 of rubber cement or the like soft or flexible binder, and a coating 127 of fibrous material such as cotton flock or linters. It will be noted that the ends of the individual fibers are deeply embedded in the cementitious layer 126 and are disposed in uniformly spaced relation with their body portions extending outwardly in substantial parallelism, thus presenting an appearance which simulates that of a pile fabric.

The embodiment shown in Fig. 16 is similar to that shown in Fig. 15 except that the backing sheet consists of a sheet of heavy paper 128 and the fibers of the coating 127 are disposed at an angle of 45° to 90° relative to the backing sheet 128, thus presenting an appearance resembling suede.

The products shown in Figs. 15 and 16 are greatly superior to those made in accordance with the prior practices wherein the fibrous material is deposited on an adhesive surface of a backing sheet by means of a current of air or by gravity. In such products the individual fibers are heterogeneously disposed on the surface of the adhesive and hence do not assume any definite position relative to each other. Consequently, such products do not possess the dense and uniform characteristics nor the attractive appearance or finish of those made in accordance with the present invention. Moreover, the wearing qualities of such products are greatly inferior to those made in accordance with the present invention due to the fact that the individual particles are not embedded to a sufficient extent, if at all, in the adhesive, and as the body portions and the ends of the individual fibers provide the surface of the product, the individual fibers are soon worn away or are easily dislodged from the adhesive and hence expose uncoated areas of the binder. In the products made in accordance with the present invention the individual fibers, being firmly embedded in the adhesive, are not easily dislodged and as their ends constitute the major portion of the surface of the product, they effectively resist wearing. Furthermore, due to the fact that a much denser coating may be applied to the adhesive surface of the backing sheet, there is a greater number of fibers per unit area to resist wearing and abrasion, and consequently the product will outwear those made in accordance with the prior practices.

While there are shown and described different desirable embodiments of the present invention, it is to be understood that this disclosure is for the purpose of illustration only and that various changes and modifications may be made without departing fpom the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In the process of coating a surface with solid particles wherein said particles are to be adhesively united to said surface, and which

complish forming an electrostatic field between a projecting and receiving electrode, the steps which include positioning an adhesively coated surface in said field, imparting an electrostatic charge of the same polarity as that of the projecting electrode to substantially all of the particles to be coated before they enter said field and then introducing the particles thus charged into said field in a position to be impelled, oriented and deposited by said field upon said adhesive surface.

2. The process of claim 1 in which the charge that is imparted to the particles before introducing them into said field is imparted by contacting the particles with an electrically charged body outside of said field.

3. The process of claim 1 in which the charge that is imparted to the particles before introducing them into said field is imparted by contacting the particles with an electrically charged body outside of said field, said charge being of a potential at least as great as that of the projecting electrode of said field.

4. In the process of coating a surface with finely divided particles of solid matter wherein said particles are to be held to said surface by firmly embedding at least a part of each particle in a coating of adhesive thereon, and wherein the particles are brought into contact with and positioned on the surface by means of the projecting, orienting and depositing effect of an electrostatic field formed between a projecting and receiving electrode, and in which the field above would charge the majority of the particles otherwise than by contact with any of the field electrodes, the steps comprising substantially separating and charging substantially all of the particles by contacting them with an electrically charged body having the same polarity and of a potential at least as great as the potential of the projecting electrode of said field before introducing them into said field, positioning the adhesive coated surface in the field and then introducing the thus charged particles into the field between the adhesive coated surface and the projecting electrode thereby insuring substantially uniform behavior of substantially all the particles that enter the field throughout the coating process and insuring that the maximum projecting, orienting and depositing power of the field is exerted on substantially every particle whereby a product coated with solid particles which are adhesively united thereto is secured, in which the particles are uniformly oriented, disposed and positioned, and firmly retained in the adhesive.

5. Apparatus for applying coating particles to a base member having a surface previously rendered adhesive, comprising a pair of spaced electrodes cooperating to form a projecting and receiving electrode assembly, means for charging said electrodes with opposite electrostatic charges thereby to produce an electrostatic field, means for supporting said base member with said adhesive surface between said electrodes, means positioned outside of the effective field between said electrodes, for imparting an electrostatic charge to substantially all of a dispersion of coating material in particle form to be applied to said base member and of a polarity corresponding to the polarity of a projecting electrode of the said assembly, said last mentioned means being positioned to conduct the charged coating particles into the said electrostatic field between the spaced electrodes intermediate the adhesive coating of said base member and the adjacent projecting electrode.

6. Apparatus for applying coating particles to a base member having a surface previously rendered adhesive, comprising a pair of spaced electrodes cooperating to form a projecting and receiving electrode assembly, means for charging said electrodes with opposite electrostatic charges thereby to produce an electrostatic field, means for supporting said base member with said adhesive surface between said electrodes, means positioned outside of the effective field between said electrodes, for imparting an electrostatic charge to substantially all of a dispersion of coating material in particle form to be applied to said base member and of a polarity corresponding to the polarity of a projecting electrode of the said assembly, and means for conducting the charged coating particles into the said electrostatic field between the spaced electrodes intermediate the adhesive coating of said base member and the adjacent projecting electrode.

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Vice President,
Executor of the Last Will and Testament of James S. Bangar, deceased.

CERTIFICATE OF CORRECTION.

Patent No. 2,287,857. June 30, 1942.

JAMES S. BANGS, DECEASED, BY GRANITE TRUST COMPANY, EXECUTOR.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 9, for "Substituted for abandoned application" read --Continuation of application--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of September, A. D. 1942.

(Seal)

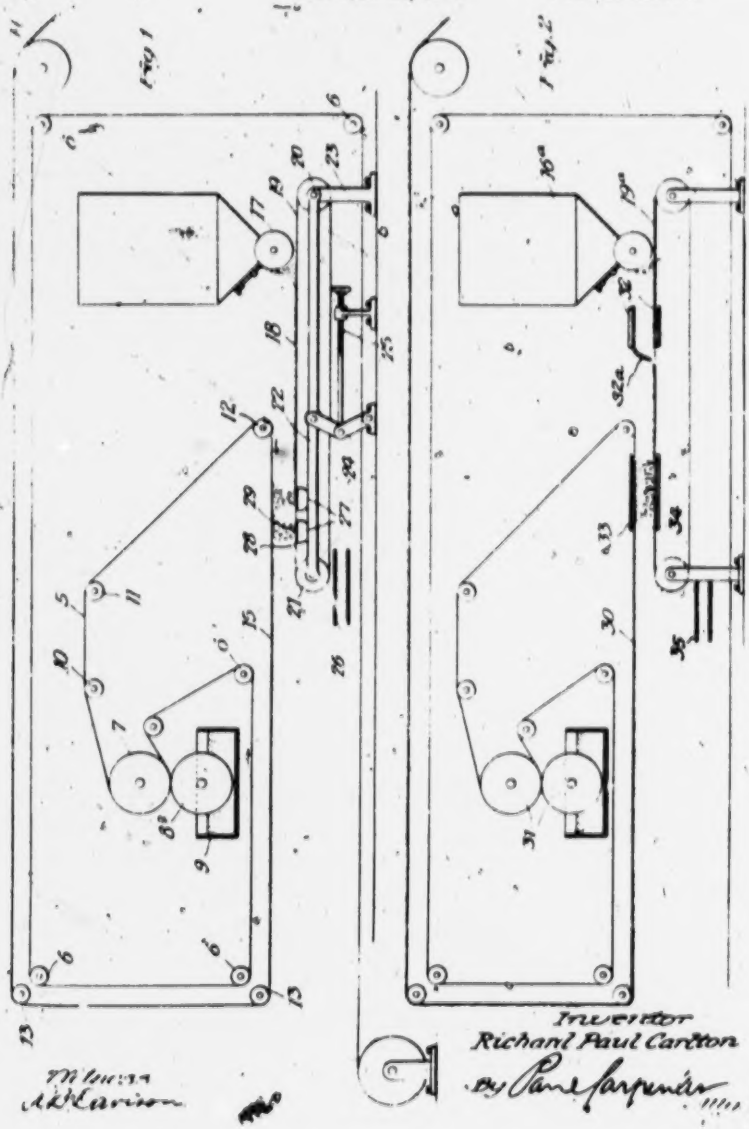
Henry Van Arsdale,
Acting Commissioner of Patents.

[fol. 584]

May 4, 1943. R. P. CARLTON 2,318,570

MANUFACTURE OF ABRASIVES

Filed Jan. 20, 1930 5 Sheets-Sheet 1



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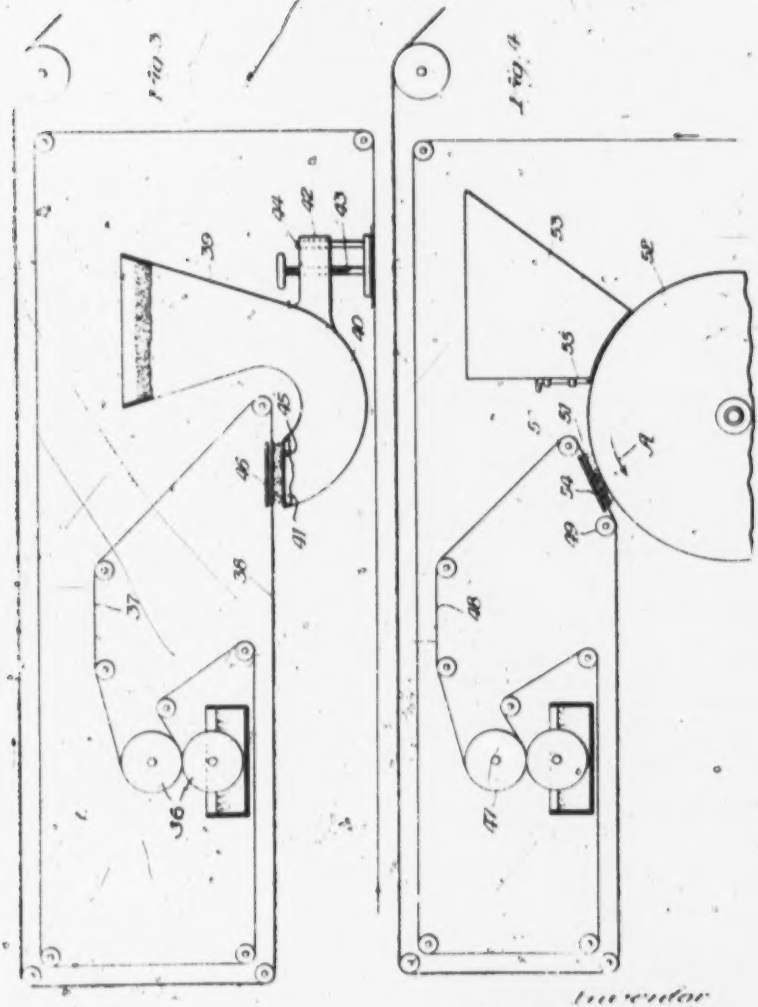
[fol. 585]

May 4, 1943. R. P. CARLTON 2,318,570

MANUFACTURE OF ABRASIVES

Filed Jan. 20, 1930 5 Sheets-Sheet 2



Witness

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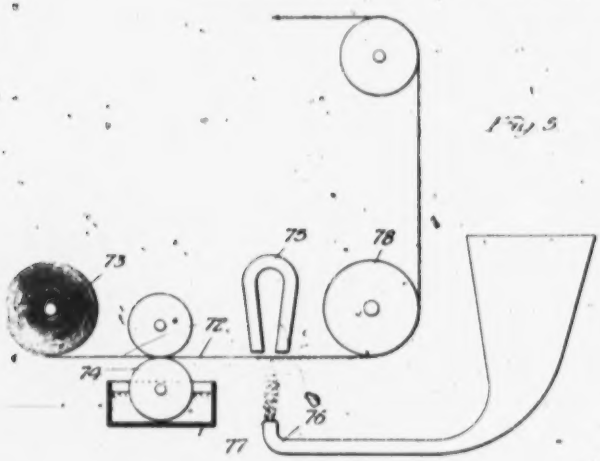
MANUFACTURE OF ABRASIVES

Filed Jan. 20, 1930 5 Sheets-Sheet 3

Fig 5



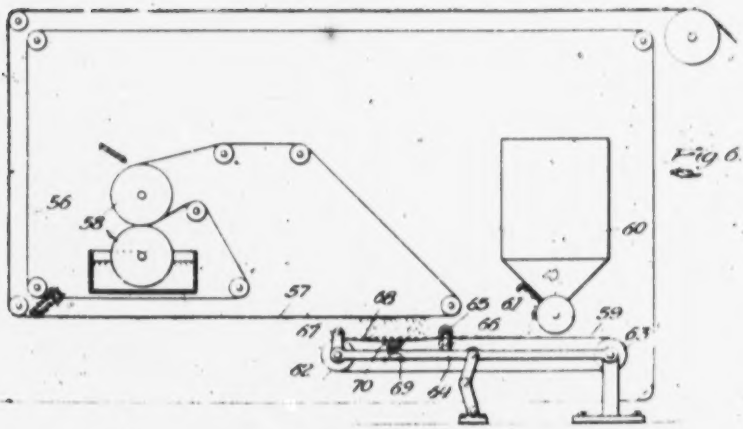
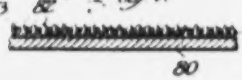


Fig 6.

Fig 7.



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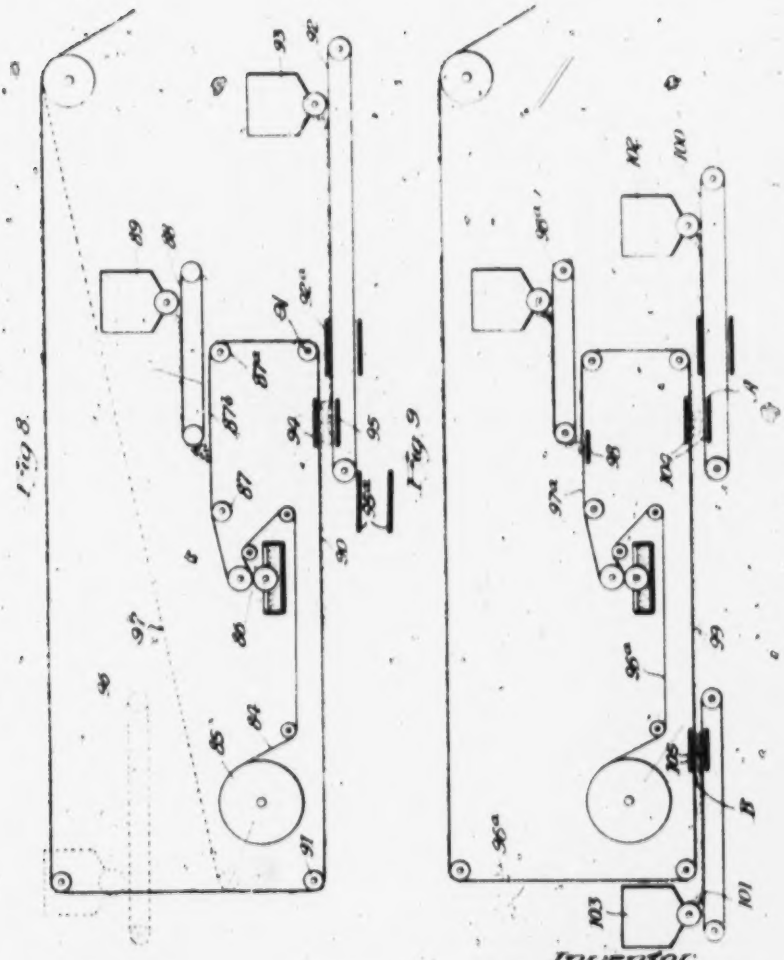
May 4, 1943. R. P. CARLTON 2,318,570

MANUFACTURE OF ABRASIVES

Filed Jan. 20, 1930 5 Sheets-Sheet 4



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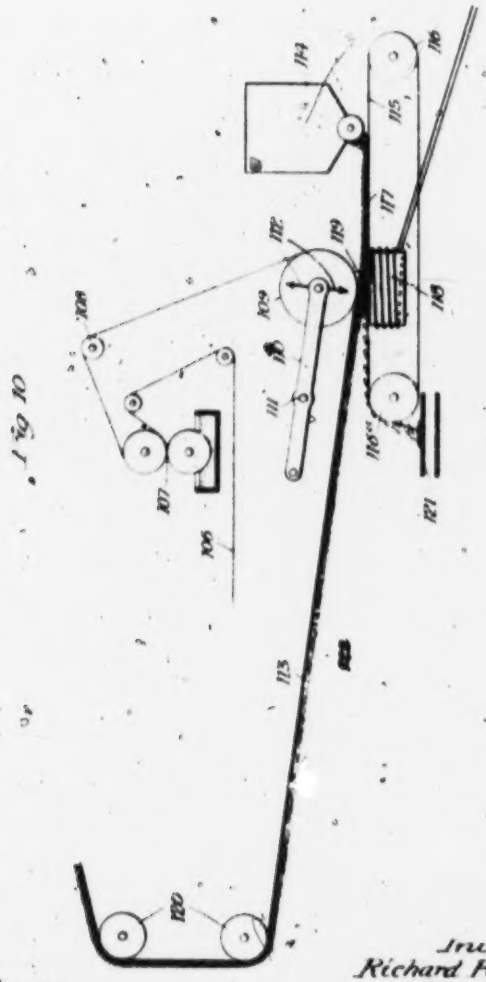
[fol. 588]

May 4, 1943. R. P. CARLTON 2,318,570

MANUFACTURE OF ABRASIVES

Filed Jan. 20, 1930 5 Sheets-Sheet 5



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Patented May 4, 1943 2,318,570

UNITED STATES PATENT OFFICE

2,318,570

MANUFACTURE OF ABRASIVES

Richard Paul Carlton, St. Paul, Minn., assignor to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware

Application January 29, 1936, Serial No. 62,865

62 Claims. (Cl. 117—17)

This invention relates in general to coated articles and to the art of coating, and more particularly to an improved method of and apparatus for applying pulverulent coatings to suitably adhesively coated surfaces, and while the invention finds particular utility in the art of making flexible abrasives, and is, therefore, described and illustrated for this purpose, it finds a wide field of utility for analogous purposes.

It is well known that in the art of making sandpaper, emery paper or cloth and similar abrasive articles, a flexible, or in some cases, a rigid, backing of paper, cloth, wood or the like is employed, to which is applied a coating of an adhesive substance, such as animal or vegetable glue, or where a waterproof article is desired, the backing may be coated with any of the now well known waterproof adhesives of the Okie Patents 1,949,827, 1,949,828, of Dec. 8, 1933, or 1,981,697 of April 20, 1934, for this purpose, and while the coating is still wet or unset, a suitable abrasive material such as garnet, corundum, sand or the like is applied thereto. The grains of abrasive substances are usually applied by gravity upon the upper adhesive coated surface of the backing and they lie in the adhesive material in haphazard fashion due to the elongated nature of the abrasive particles, and in a large degree, the facets or cutting edges of the individual grains or grits often lie flat upon or are embedded in the adhesive coating in such a manner that in some instances their best cutting edges never come into contact with the work or at best are brought inefficiently into contact therewith. The invention here has as one of its objects to measurably increase the number of grits whose longer or greater dimensions are in a plane perpendicular to the surface of the backing, thereby to present more efficiently the cutting edges to the work, and increase the cutting ability and life of the abrasive article.

It will be understood that in ordinarily depositing mineral, that is, pulverulent abrasive material solely under the force of gravity onto a backing, it acquires a velocity due to the action of gravity. As the grits pass through the intervening air space, there will be caused some change in their positions enroute to the sheet or backing but ordinarily neither the velocity given to the grits or the effect of the air on them is sufficient to cause them to become aligned so as to assume positions substantially perpendicular to the backing. It is, therefore, necessary that independent force be applied to the grits and I have found that by passing the grits through a static field of electric energy or of electro-magnetic energy or by mechanically imparting this force to the grits a much greater number of the individual particles will assume erect positions on the backing which will enhance its cutting ability. As will later appear, my invention, in its several forms, is capable of application for operation in conjunction with gravity methods of applying the grit, inasmuch as under certain conditions, and for some purposes, it is desirable to employ both gravity and one of the forms of my invention in conjunction in order to attain a desired form of abrasive article.

In carrying out this invention, I find it desirable to employ a conveyor for conducting the mineral at rest relative to the conveyor by relatively slow speed to a point adjacent to which the independent force is applied for projecting the particles of grit onto the backing. I find that by then applying this independent force, be it mechanical or electrostatic or electromagnetic, I am able to impart a high velocity to the particle so that any force of gravity acting on the particle, whether in the same direction, in a counter direction, or in a direction angularly to that at which the force is applied, will be relatively small compared to this force applied. It is possible with the present invention to apply the force directly counter to gravity, that is, by bringing the grits beneath the backing or by applying the force in some other direction as long as the force of gravity and the effect of air is reduced below a point which will interfere with the result desired, namely, the projection of the grits with their longitudinal dimensions ultimately perpendicular or substantially so with respect to the backing.

The principal objects and advantages of this invention reside in the provision of an improved abrasive coated article, such, for example, as sandpaper, emery cloth, or the like, wherein the abrasive grits or grains lie in position on the backing for increasing the cutting effect and durability of the abrasive article; the provision of an improved abrasive article wherein the abrasive grits are disposed so that their cutting facets are presented in position to more efficiently engage the work and thereby produce a sharper article; the provision of an improved abrasive article wherein the abrasive grains or grits are applied thereto with their longer or greater dimension substantially perpendicular to the plane of the backing; the provision of an

improved abrasive article which may be flexible or rigid, as desired, and which may or may not be made waterproof, that is, suitable for employment in a water abrading operation.

This invention further includes as objects and advantages thereof, the provision of an improved method of an apparatus for manufacturing abrasive articles; the provision of an improved method of and apparatus for applying pulverulent material to one surface of a backing irrespective of the force of gravity, that is, against the normal tendency of the force of gravity; the provision of an improved method of and apparatus for propelling a pulverulent material, such as a grit or an abrasive grain, against an adhesive coated surface; the provision of an improved method of and apparatus for the purpose set forth and including electrically operated means for acting on an abrasive grain or pulverulent material and causing it to advance onto the adhesive coated backing irrespective of the force of gravity; the provision of an improved method of and apparatus for causing the particles of pulverulent material to impinge upon and assume a position in the adhesive coated surface substantially normal or perpendicular to the surface of the backing; the provision of an improved method of and apparatus for propelling a pulverulent material onto a moving sheet in a direction transversely to the plane of movement thereof and in a direction substantially counter to gravity; the provision of an improved method of and apparatus for making abrasive articles, such as sandpaper and the like, which includes the application of a grit to the under side of the backing; the provision of an improved apparatus which includes means for feeding and applying a pulverulent material counter to the force of gravity and simultaneously with movement of the backing; the provision of an improved means for moving a web of paper and applying an adhesive thereto and including means arranged below and for operating synchronously with for applying a pulverulent material to the under side of said moving backing; and the provision of an apparatus of the character described wherein improved electrostatic or electromagnetic means may be employed, acting on the abrasive material and causing it to move at an accelerated speed toward the sheet so as to cause it to impinge thereon in the adhesive coating and thereby present the cutting edges of the abrasive grits away from the surface of the backing and thus increase the cutting ability and life of the abrasive article.

I have also found my invention useful as a modifying step in the employment of the conventional gravity process for applying grit in the manufacture of sandpaper or other abrasive and, therefore, additional objects of this invention reside in the provision of an improved method of interposing an additional step which will apply abrasive grains either before or after the application of grits by gravity in the usual manner, it being understood that the step of applying grit irrespective of gravity by an electromagnetic or electrostatic means may be employed somewhere in the process of manufacture, the essential purpose being to increase the number of grits whose cutting facets are presented away from the backing and thereby to enhance the cutting ability of the finished article.

The apparatus of this invention includes a number of alternative forms for mechanically or electrically carrying out the steps of the process and to this end is provided an improved pneumatic means and improved vibrator structure for mechanically propelling the pulverulent material and improved electromagnetic structure for acting on the mineral and causing it to move in a cloud toward the adhesive coated surface of the moving web or backing.

The foregoing and such other objects and advantages as may appear or be pointed out as this description proceeds are attained in the structures illustrated in the accompanying drawings in which:

Figure 1 is a schematic view illustrating one form of apparatus for carrying out the process of this invention;

Figure 2 is a view similar to Figure 1 of an alternative form of the invention;

Figures 3, 4 and 5 are further alternative forms of the invention which include the electrical feature;

Figure 6 is a further alternative form of the apparatus of this invention of employing mechanical vibrating means;

Figure 7 is an enlarged schematic view illustrating a portion of an abrasive article made in accordance with this invention;

Figures 8 and 9 are additional alternative forms of apparatus for carrying out further steps of the process of this invention;

And Figure 10 is a further alternative form of apparatus for carrying out one of the methods of this invention.

The method of the present invention includes as steps thereof the feeding of a web or strip of paper or other fabric at a predetermined rate of speed, applying an adhesive substance to the under side of the sheet, or applying the adhesive coating to one side and then moving the sheet with the coated side out, and simultaneously with the movement of the coated sheet, causing a grit or abrasive material to be applied to this side. The sheet or web of paper may be moved so that the adhesive coated side is either presented downwardly or at any angle thereto. The movement of the abrasive grains onto the under side of the backing is done irrespective of the force of gravity and, in fact, directly counter to gravity, and preferably done by imparting relatively high velocity to the abrasive material, thus causing it to impinge upon the adhesive coating. In view of the fact that the abrasive grains are projected through an intervening space from a suitable carrier onto the adhesive coated side irrespective of or counter to the force of gravity, the grains, which are usually somewhat elongated, will assume a position in transit so that the longer dimension thereof will take a position normal to the surface of the backing, thus causing the grains to "stand" on the surface rather than lie flat in greater percentage than when they are deposited by gravity. It is to be understood that this movement of the grains and deposition of them on the coated surface may be carried out in a number of ways, either by vibration, by an air blast, or by electrostatic or electromagnetic means.

In the alternative forms of this invention later to be described, the method involved includes combining a gravity deposition of mineral on the adhesively coated moving backing with the step of applying the grits irrespective of gravity, this being particularly useful in some of the heavier grits wherein it may be found that the force susceptible of application by an electrostatic or an electromagnetic means is not sufficiently active on

the available area of the individual grits to cause an entirely satisfactory result or to move enough of the grits onto the sheet to attain the desired end. In this invention it may be required to apply some of the grit by gravity and later apply some of the grit by one of the methods of this invention or vice versa, but, in any event, the number of grits in the entire finished article which stand erect on the backing will be measurably increased over the ordinary methods heretofore employed for depositing grit on a backing for forming an abrasive article.

This invention produces a very satisfactory piece of sandpaper in which the cutting ability is measurably increased and by the deposition of the grains of sand or grit irrespective of the force of gravity, it is possible to produce an orientation of the mineral as desired and to control the thickness of the abrasive coating much more readily than where gravity alone is relied upon or employed for depositing the grains on the sheet.

The apparatus of this invention may take any one of the forms shown in the drawings and in the form of the invention shown in Figure 1, air pressure is resorted to for producing the mineral cloud and for projecting the mineral onto the moving web.

Referring now more particularly to Figure 1, the flexible backing 6 of paper or cloth or other fabric is trained or fed over a series of rollers 6, 6, and over one of a pair of the squeeze rollers, indicated at 7, the other roller 8 of said pair being in contact with an adhesive material contained in a tray or tank 9 by which an adhesive coating is applied to one side of the moving web. After receiving the adhesive coating, the web 6 is trained over rollers 10 and 11 and is brought back over a roller 12 so that the adhesive coated surface of said web is presented downwardly. The web may then be trained over rollers 13, 13, and fed to a suction drum 14, whence it passes into festoons for drying.

The mineral is supplied from a hopper 16 and a conventional outlet 17 which feeds a layer 18 of mineral to a moving conveyor 19. This conveyor 19 is preferably porous and passes over the feeding rollers 20 and 21 and is adapted to move at a suitable rate of speed to supply a sufficient quantity of abrasive grain. In some cases, it has been found advantageous to move the conveyor at a speed substantially the same rate of speed as the web 18, although these speeds are, of course, variables. The rollers 20 and 21 are mounted in the ends of a suitable frame 22 and this frame may be raised and lowered so as to vary the distance between mineral conveyor 19 and the moving web 18. This frame 22 may be supported fixedly at one end, as indicated at 23, and the other end may be raised and lowered by a toggle arrangement 24 activated by a threaded rod 25. Below the conveyor 19 and at the movable end thereof, that is, adjacent to the web 18, there is provided a second conveyor 26 which serves to conduct away excess mineral which flows over the end of the conveyor 19 and which may be returned in any suitable manner to the mineral hopper.

Below the upper flight of the conveyor 19, there are provided two air troughs 27. These air troughs are provided with flat upper walls 28, having slots 29 therein, said slots extending across the width of conveyor 19 and the troughs themselves being connected to a suitable source of air under pressure.

These troughs form in effect elongated jets or nozzles and when so placed below the conveyor belt or frame 22, a small quantity of air is emitted at high velocity which passes through the porous belt or conveyor.

It will be understood that when a blast or blasts of air are delivered from the troughs 27, this blast of air passes through the porous conveyor 19 and blows the mineral from the conveyor against the under side of the flight 18 so that the mineral is caused to strike into the adhesive at a relatively high velocity and become impinged therein. Owing to the projecting of the mineral in this manner through the intervening air space, the individual particles of grit or abrasive material are caused to assume a position parallel to their trajectory, that is, with their longer dimension perpendicular to the surface of the flight 18. In view of the fact that most of the particles of mineral are somewhat elongated due to the manner of production of the same, they will naturally assume this position in movement from the conveyor 19 to the adhesive coated surface of the backing. As they arrive at the adhesive material, they impinge themselves thereon and will thus stand erect in the adhesive, thus forming a sharper contour for abrasive purposes. By varying the rate of speed of the moving backing relatively to the speed of the conveyor and by varying the distance between the conveyor and the backing and the velocity of the air stream, and by increasing or reducing the number of such jets and the quantity of adhesive applied, any reasonable desired thickness of grit layer may be produced during the process and without stopping the apparatus. It will be understood that the excess mineral carried by the conveyor may be dumped into the conveyor 26 and returned by any suitable means to the hopper 16.

Referring now to Figure 2, there is provided the same general arrangement of moving backing, having the flight 30 adhesively coated from the squeeze rollers 31.

Below the flight 30 there is provided a mineral feeding conveyor 19a, receiving pulverulent material from the hooper 16a.

The conveyor 19a is mounted for movement toward and away from the flight 30 similar to the conveyor 19 and, therefore, this structure has not been shown in Figure 2.

As the mineral flows from the hopper 16A it does not always assume a smooth or even distribution on the conveyor 19A, and, therefore, it may be desirable to provide a pair of charged electrodes 32, one arranged above and one below the conveyor 19A, for the purpose of spreading the mineral evenly on the conveyor belt. The conveyor 19A in this instance may be non-porous.

When charged electrodes are put in this position they act in principle the same as the charged electrodes used for coating the mineral on the backing. An electrical charge or difference of potential is set up between the electrodes 32. The voltage or difference in potential between these electrodes is maintained great enough to produce a strong static field, but not so great as to break down the insulation between the plates, which insulation may be the dielectric strength of the air or the dielectric strength of the air plus the dielectric strength of any insulating material which may be used to wrap the electrodes.

As the mineral on the conveyor enters the static field between the plates the mineral particles take on the charge of the lower plate, and

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are repelled to the upper plate where they lose their charge and take on the opposite charge of the upper plate. At this point they are repelled to the lower plate. Since new mineral is being conveyed by the conveyor into the field continuously the static fields soon become supersaturated with mineral particles, and an equilibrium is reached where as many particles are thrown out of the static field as are brought in by the conveyor. By having a down-turned end 32A of the upper electrode the mineral particles that are thrown out of the static field are deflected evenly on the conveyor belt so that a smooth coating of abrasive grit is first placed on the conveyor.

The use of a static field for getting a smooth coating of mineral on the conveyor belt is not necessary to the invention but is an additional means of obtaining evenly distributed abrasive coatings, and is also a means for avoiding the use of any excess mineral on the conveyor. When the mineral is evenly coated on the conveyor at the time it is being coated streaks, thin spots, etc., in the finished product are reduced.

At the same approximate point at which troughs 27 are provided in Figure 1 there are here provided electrically charged electrodes 33 and 34, the electrode 34 being located below the upper flight of the conveyor belt 19A and electrode 33 being disposed above the flight 38 of the backing. A sufficient difference of potential is maintained at electrodes 33 and 34 to produce a strong static field, similarly to that referred to above. This static field moves the mineral from the belt 19A to the underside, which is the adhesive coated surface of the flight 38.

As the mineral enters the static field between the electrodes 33 and 34 it becomes charged with the charge of the lower plate, and is here propelled to the upper plate 33.

It will be observed that in this method of coating the mineral is applied by a force other than gravity. In all other methods of coating sandpaper, known to me, the velocity of the particle is either in whole or part given to it by the force of gravity. In the case of this electrostatic coating the particles are oriented in the static field so that there is a tendency for the long dimension of the mineral to be perpendicular to the electrode plates, and also perpendicular to the web 38, which is being coated. The finished sandpaper product, therefore, contains a substantial percentage of the particles of mineral standing on end rather than laying flat, thereby increasing the cutting properties of the abrasive article.

Excess mineral is dumped onto the conveyor 38, whence it may be returned to the hopper 16a.

Referring now to the alternative form of the invention shown in Figure 3, there are provided the squeeze rollers 36 which apply adhesive to one surface of the moving paper web 37 and the adhesive coated surface thereof is presented downwardly in the flight 38.

In this instance there is provided a hopper 39, having a curved outlet spout 40 whose outlet 41 is presented below the moving web 38. The hopper may be provided with a bracket 42 whereby to receive a threaded member 43, said bracket engaging a guide post 44. In this manner, the hopper may be raised or lowered so as to vary the distance of the outlet 41 from the flight 38 of the backing. A suitable screen 45 may or may not be provided over the outlet so as to cause the distribution of the mineral contained in the hopper. In this instance, the mineral flows by gravity to the outlet 41, but does not pass from the outlet to the adhesive coated backing by gravity, but under the effect of the static charge established between the electrode 46 and the hopper or the screen 45 of said hopper.

The operation of the invention here is much like that of Figure 2, the screen 45 serving the purpose of distributing the mineral and at the same time preventing the large body of mineral in the hopper from forcing it against the coated surface of the backing.

Referring now to the form of the invention shown in Figure 4, there is provided the adhesive coating rollers 47, applying an adhesive coating to one surface of the moving web 48. This web 48 is trained over rollers 49 and 50 so that flight 51 thereof between said rollers is presented in a plane tangential to the surface of a conveyor drum 52 whose lineal velocity is sufficient to furnish the required amount of mineral. This drum is fed from a hopper 53 and forms one electrode of the electrostatic system. The other electrode is indicated at 54 and is disposed above the flight 51. As mineral issues from the gate 55 of the hopper, the drum rotating in the direction of the arrow A, the mineral is carried to a point adjacent to the flight 51 whereupon the electrostatic charge set up between the drum 52 and the electrode 54 will cause a projection of the mineral from the drum onto the coated surface of the flight 51.

Referring now to the alternative form of the invention shown in Figure 5, there is employed here electromagnetic means or a permanent magnet means for moving the grits toward the adhesively coated web. The adhesively coated web is shown at 12 and is fed from a roll 13 over an adhesive coating roller 14. The horizontal flight of the web 12 passes beneath magnet 15 which may be either an electromagnet upon which a variable voltage may be imposed or a permanent magnet.

Immediately below the magnet 15 and the flight 12 of the web, there is provided a source of supply for the mineral, that is, the abrasive material, indicated at 16. This source includes an outlet 17, and the distance between the outlet 17 and the moving web 12 may be varied as desired, or the intensity of the electromagnet, where one is employed, may be varied for changing the thickness of the abrasive coating. The web passes over an idler 18 whence it is fed to festoons not shown.

Referring now to the form of the invention shown in Figure 6, the moving web 56 is trained over a series of rollers similar to the arrangement shown in Figures 1 and 2 so that a horizontal flight 57 of the paper backing is provided, having an adhesive coating on the under side thereof. Squeeze rollers 58 engage the paper backing for applying an adhesive thereto.

In this form of the invention, a mechanical vibrating means is provided which serves to propel the mineral, that is, the grit, from the grit feeding conveyor 60, which latter receives mineral from the hopper 59, having a gate 61. The conveyor 60 is trained over rollers 62 and 63 mounted in a suitable frame 64, which latter may be mounted for adjustment toward and away from the flight 57 similarly to the conveyor 19 of Figure 1. The conveyor 60 extends below and is separated from the flight 57 of the paper web and travels at substantially the same speed as the paper web.

The conveyor 60 passes between sets of pinch

rollers, one above and one below the upper flight of the conveyor 50, as indicated by 55 and 56, and also beneath a pinch roller 57 which bears on the roller 52. The pinch rollers 55 and 56 tend to distribute the mineral evenly over the surface of the conveyor and are so spaced from the rollers 52 and 57 that the portion of the belt 58 between the rollers 55 and 56, and 52 and 57 is permitted to lie slack whereas the remaining part of the conveyor is substantially taut. This arrangement tends to limit the vibration of the conveyor belt to the zone of application of the mineral to the paper backing, as indicated at 58.

Beneath the portion 58 of the belt 59, there is provided a revolving batter 59 operating on a shaft carried in suitable bearings in the frame 64 and provided with a plurality of radial arms 76 which upon rotation rigidly strike the under side of the portion 58 of the belt, thus throwing or projecting the mineral content thereof against the under side of the adhesive coated paper backing, much in the manner in which the air stream blows the mineral or grit against the paper backing as shown in Figure 1. The batter 59 may be driven in any desired manner from a separate source of power or may be connected suitably with the rollers driving the belt 58, but geared to operate at a greater rate of speed. The rollers 55 and 56 and the roller 57 are separately driven from the belt 59 so as to produce the tautness in the belt, except the flight of the belt indicated at 58.

In Figure 7, there is illustrated an article made in accordance with the present invention. The backing is shown at 60 to which an adhesive coating 61 has been applied, and the grits, greatly enlarged, are indicated at 62 and it is noted that they stand on end in the adhesive coating, thus causing their sharper edges to project beyond the upper or outer surface of the coating, thereby enhancing the cutting ability and increasing the life of the abrasive article. While the article shown in Figure 7 is purely schematic, it will be understood that the mineral actually does take a position substantially normal to the backing and, while all of the grits may not take this position, a large number of the same do and the cutting qualities of the abrasive article are thus greatly increased. Furthermore, by so disposing the grits, it permits of the application of an additional sizing coat or coats to the back and to the front or cutting face of the abrasive material without completely burying the grits and as a thicker coat of adhesive may thus be employed on the cutting face of the abrasive material, the engagement of the adhesive material with the abrasive material is greatly enhanced, thus further tending to increase the life of the abrasive article. Such a sizing coat is indicated at 63.

As previously pointed out where the electrostatic or electromagnetic methods are resorted to in some of the coarser grades of abrasive devices made, it may be found that the electrostatic or magnetic field into which the particles are conducted may not exert on each individual particle sufficient force to cause proper orientation of the particles for the reason that the static effect is substantially proportional to the area of the particle and the coarser the particle, the smaller the area of effect per weight. Therefore, as larger grits or sizes of particles are employed, increased force is required to move the particle and for some purposes, insufficient increase in force results because of the reduced area per weight. Therefore, in such cases a form of the invention, as shown in Figure 8, may be resorted to wherein the mineral is applied to the adhesive coated backing in part by gravity and in part by electrostatic or electromagnetic means.

In view of the fact that the electrostatic and electromagnetic means may for some purposes be alternatively employed, I have illustrated in Figure 8 merely the electrostatic elements though it will be understood that the electromagnetic means of Figure 5 may be employed in the same manner.

Referring in detail to Figure 8, I have illustrated a web of paper 84 coming off a roll 85 and passing through an adhesive coating device illustrated in general at 86. The web 84 is thence trained over rollers 87, 87a, so that it has a substantially horizontal flight 87b, which receives grits in the desired amount from an ordinary conveyor 88, said conveyor receiving grits from the hopper 89. The web of paper thence is carried downwardly to a horizontal flight 90 by the provision of rollers 91, 91 and adjacent one end of this flight, I provide the conveyor 92 receiving additional grits from the hopper 93, which may be adjustably mounted similar to the conveyors hereinabove described, said conveyor 92 passing beneath the flight 90 of the paper web. As the web passes over the rollers 87a and 91, a quantity of the mineral deposited from the conveyor 88 onto the web will drop off, and, for conveying away this excess mineral, I provide a transversely running conveyor 92a arranged between the flight 90 and the conveyor 92. Beneath the upper flight of the conveyor 92 and above the flight 90 of the web 84, I provide static electrodes 94 and 95, or may provide an electromagnet similar to that shown in Figure 5 which will cause grit coming from the hopper 93 to be applied counter to the force of gravity onto the under surface of the flight 90. A conveyor 96a may be employed for carrying off the excess mineral from the conveyor 92.

In the operation of this form of the invention, it will be understood that a desired proportion of mineral applied by gravity to that applied by force other than gravity may be determined by actual operation so that the desired quantity of the abrasive grits is properly applied to the paper web.

It may be necessary in some of the very coarse grains to additionally apply grit to the moving web and this may be done by providing an additional conveyor similar to that indicated at 92 and additional electrodes, or may be accomplished by additionally applying by gravity grit at the point indicated at 96, this arrangement being shown in dotted lines and the grits being applied to an upper flight 97 of the paper web just before it passes on to the festoons.

Figure 9 illustrates the alternative forms suggested in connection with Figure 8, that is, wherein electrostatic or electromagnetic means or any other means counter to gravity, is employed for applying the grits and in Figure 9 the paper web is indicated at 98a having a horizontal flight 97a disposed below a conveyor 88a. In this instance, the grits are deposited from the conveyor 88a by gravity and the orientation of the grits is assisted by a plate electrode 99. The paper web may then be carried in position so as to provide a horizontal flight 90 and an electrostatic or electromagnetic or other grit applying

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means for applying grit counter to gravity may be employed at one or more points as indicated at A and B, wherein the conveyors 180 and 181 convey grit from suitable hoppers 182 and 183, and electrodes 184, 184, and 185, 185 serve to apply the grit.

Referring now in detail to Figure 10, there is further illustrated there an apparatus for applying the grit to the adhesively coated backing by an electromagnetic means. In this form of the invention a moving web is provided indicated at 186, this web being a flexible strip of paper which is suitably adhesively coated by a mechanism indicated generally at 187.

The moving web thus adhesively coated is carried over a roller 188, thence over a roller 189, said roller 189 being mounted on a shaft carried in a bearing arm or arms 110 pivotally mounted at 111, whereby the roller 189 may be raised and lowered in the substantially vertical plane of the arrows 112, thus permitting the lower flight 113 of the paper web to be elevated or depressed, as the case may be.

Mineral is deposited from a hopper 114 on to a conveyor 115 trained over rollers 116 and 116a, the upper flight 117 of said conveyor passing beneath the roller 189 and the moving web, and conveying mineral, that is, the grit, to a point adjacent to the roller 189.

Preferably immediately below the axis of the roller 189 and below the upper flight 117 of the conveyor 115 I provide an electromagnet 118 which is so mounted that its magnetic flux passes through the conveyor and causes the mineral particles to stand erect, as indicated at 119, as they move along with the upper flight of the conveyor. While the mineral particles are thus standing erect they come into contact with the adhesively coated side of the paper backing and are thus picked up by it and conveyed away, the backing being trained over rollers 120 and carried to the festoons similarly to the other forms of the invention. It will be observed that the angularity of the lower stretch 113 of the paper web is such that lies upwardly to the conveyor 115. In this way the particles of grit adhering to the paper are not knocked down by other particles remaining on the conveyor, it being understood that the grid is fed somewhat in excess of the required amount so that an adequate amount will be deposited on the adhesively coated side of the backing. The excess mineral drops off the conveyor 117 and is carried to a collecting means by a conveyor 121.

It will be understood that by varying the amount of mineral fed from the hopper, the strength of the electromagnet, that is, the strength of the flow current transferred, and the position of adjustment of the roller 189 the assembly may all be properly correlated for obtaining the desired grade of finished article.

It may be desirable that a certain amount of pressure be exerted on the erect particles of mineral so as to cause them to impinge upon the adhesively coated side of the paper and thus, by manipulation of the arms 110, an adjustment of the pressure of the roller 189 may be attained.

It will be understood that while the electrostatic and electromagnetic means for casting counter to gravity are illustrated in Figures 8 and 9, the mechanical means hereinabove described may be conveniently employed in these locations without departing from the spirit of the invention. However, the reason the electromagnetic and electrostatic elements are particularly shown here is that the difficulty of counter coating successfully with the coarser grains is more likely to arise with these elements than with the vibrator or air blast heretofore described.

I wish to point out that where the expressions "electromagnetic" and "electrostatic" are employed in the specification, I will refer to the employment as well of a permanent magnet or some other form of static charge or magnetic charge which will perform the function.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is:

1. The method of coating a continuously moving backing with a pulverulent material which includes as one of its steps the propulsion of the pulverulent material from a preliminarily distributed layer thereof onto one surface of the backing in a direction resisting the normal force of gravity and arranging the pulverulent material on end.

2. The method of making an abrasive article having a backing and a grit layer which includes as steps thereof coating a backing with adhesive, and forcibly propelling a pulverulent abrasive substance to said adhesive coated surface from a preliminarily formed layer and against the normal force of gravity for causing the particles of abrasive to assume a position in the adhesive with the major dimensions thereof substantially normal to the plane of said backing.

3. The method of coating a backing with a pulverulent material which includes as steps thereof, feeding the backing at a substantially uniform rate of speed, supplying the pulverulent material to the zone of application in a substantially thinly distributed layer on a conveyor spaced from said backing, and propelling the pulverulent material from the conveyor through the intervening space onto one surface of the backing in a direction counter to the force of gravity.

4. The method of coating a backing with a pulverulent material which includes as steps thereof, feeding the backing at a substantially uniform rate of speed, in a substantially horizontal plane, feeding a pulverulent material below said backing in a substantially horizontal plane, and propelling the pulverulent material upwardly to cause the same to impinge upon one surface of said backing.

5. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive thereto, means below and spaced from said backing for supplying a pulverulent material in a layer arranged substantially in parallelism to said backing, and means for applying said material to said backing including an air jet for propelling said material against said backing through the intervening space.

6. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive thereto, means below and spaced from said backing for supplying a pulverulent electrically susceptible material, and means for creating an electrical field including electrically charged elements below said supplying means and above said backing for propelling said material onto the backing under the influence of said field.

7. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive thereto, means below and spaced from said backing for supply-

ing a pulverulent electrically susceptible material, means for distributing said material during supplying of the same, and means for creating an electrical field including electrically charged elements below said supplying means and above said backing for propelling said material onto the backing under the influence of said field.

8. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive thereto, means below and spaced from said backing for supplying a pulverulent electrically susceptible material, electrostatic means for distributing said material during supplying of the same, and means including electrically charged elements below said supplying means and above said backing for propelling said material onto the backing.

9. In an apparatus of the character described, means for applying an adhesive to a backing and for supporting the adhesive coated surface facing downwardly in a substantially horizontal plane, a hopper for pulverulent electrically susceptible material having a curved portion terminating in an outlet below and spaced from the adhesive coated portion of said backing, and means acting electrically on said pulverulent material for lifting it from said outlet and propelling it against said adhesive coated portion.

10. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive to the under side thereof, a drum for feeding an abrasive material arranged to have its surface below and spaced from said backing, which is in a plane substantially tangential thereto, and a charged electrode above said backing for creating an electrical field and for moving material from the drum to said backing and influenced by said field to cause a predetermined positioning of the particles of abrasive material in relation to the backing.

11. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive coating thereto, means for feeding said backing with the coated side down, a conveyor for abrasive material below and spaced from said backing, means for distributing abrasive material to said conveyor, and means for vibrating said conveyor for propelling the abrasive material distributed thereon therefrom to said coated backing.

12. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive coating thereto, means for feeding said backing with the coated side down, a conveyor for abrasive material below and spaced from said backing, means for distributing abrasive material to said conveyor, and means for applying an impact to said conveyor for propelling abrasive material therefrom to said coated backing.

13. In an apparatus of the character described, in combination, means for supporting a backing, means for applying an adhesive coating thereto, means for feeding said backing with the coated side down, a conveyor for abrasive material below and spaced from said backing, means for distributing abrasive material to said conveyor, means for rendering taut a portion of said conveyor and for slackening a portion thereof beneath said backing, and a batter for imparting vibrations to said slackened portion for propelling the abrasive material therefrom onto said backing.

14. The method of coating a backing with a pulverulent material which includes as steps thereof moving the backing at a substantially uniform rate of speed in a substantially uniform plane, said backing having an adhesive coating presented downwardly, feeding the pulverulent material below said backing in spaced relation thereto, propelling the pulverulent material upwardly to cause the same to impinge upon said coated surface, and varying the distance between the backing and the pulverulent material, as for varying the thickness of the coating of the latter.

15. In an apparatus of the character described, in combination, means for moving a backing of sheet material at a uniform rate of speed, means for applying an adhesive coating to one side of said backing, means arranged below and in spaced relationship to said backing for conveying an abrasive material, means for moving said abrasive material onto said adhesive coated backing through the intervening space counter to the force of gravity, and means for varying the distance between said backing and said means for conveying abrasive material.

16. The method of manufacturing abrasives which includes as steps thereof, employing an adhesively coated backing, conveying and uniformly distributing in a substantially thin layer a quantity of pulverulent abrasive material to a point adjacent to but spaced from the coated backing, and projecting the abrasive material across the intervening space onto said backing the projecting force being controlled within limits affecting the axial position of said material.

17. In the manufacture of abrasives employing abrasives susceptible to the influence of an electrical field to axially arrange themselves in respect of said field, the improved method which consists in providing a carrier having a surface coated with an adhesive, depositing said finely divided abrasive material upon said surface by a force in a direction counter to the force of gravity, and dispersing the particles by the action of an electrical field as they are being deposited upon the surface.

18. The method of manufacturing granular coated webs which comprises applying a layer of adhesive to a side of a continuously moving web, moving said web in such a manner that the adhesive coated side is positioned downward, supplying irregularly shaped granular particles to a feed belt positioned beneath said web and moving in a direction substantially parallel therewith, and projecting the granular particles from said belt onto the adhesive coated web.

19. The method of manufacturing granular coated webs which comprises supporting an adhesive coated web with an adhesive side downward, supplying irregularly shaped granular particles to a mesh conveyor belt positioned beneath said web and projecting said particles from said belt onto said adhesive coated web by means of air blown through said mesh conveyor belt.

20. The method of manufacturing granular coated webs which comprises supporting an adhesive coated web with an adhesive side downward, supplying granular particles to a conveyor belt positioned beneath said web and moving said belt over and in contact with rotating beaters.

21. The method of manufacturing flexible webs coated with upstanding abrasive grain which comprises projecting the grain upwardly against an inverted adhesive coated web so that the grain is oriented in its flight and strikes and adheres to the inverted web in a position with its major axis at a substantial angle to the surface of said web.

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22. The method of manufacturing flexible webs coated with upstanding abrasive granules which comprises selecting abrasive granules a substantial proportion of which are elongated in character, supporting an adhesive coated web with the adhesive side downward, projecting such grain upwardly against said adhesive surface in such a manner that a substantial proportion of the elongated particles are oriented in flight with their major axes at a substantial angle to the plane of said web and adhere thereto in such oriented position.

23. The method of making sand paper and other abrasives consisting in supporting the abrasive substantially parallel with the backing sheet and blowing the abrasive particles against the adhesive surface of the backing sheet to project thereinto at substantially right angles, while the backing sheet is in position to permit the surplus abrasive particles to fall away from the same.

24. A machine for making sand paper including, an endless belt carrier, a hopper and spreader for abrasive particles adapted to spread abrasive particles onto said endless belt as it travels past said hopper, and means for shooting the abrasive particles off of said belt against an adhesive surface on the paper adapted to make the abrading surface of the sand paper.

25. A machine for forming abrasive material including a porous flexible carrier belt, means for applying abrasive particles on said belt, means for supporting an adhesive coated backing sheet adjacent a portion of said carrier belt, a nozzle on the side of the carrier belt opposite the side supporting the abrasive particles, for directing a blast of air through said porous belt to blow the abrasive particles against the adhesive coating of the backing sheet.

26. An apparatus of the class described comprising a horizontally moving conveyor for abrasive particles, a horizontally moving adhesive coated web moving parallel to said conveyor above the same and having its adhesive surface exposed with relation to particles on said conveyor, and an electrical field disposed in the path of movement of said conveyor and web for propelling particles from the conveyor upwardly to said adhesive surface.

27. An apparatus of the class described comprising a horizontally moving conveyor for abrasive particles, a horizontally moving adhesive coated web moving parallel to said conveyor above the same and having its adhesive surface exposed with relation to particles on said conveyor, and an electrical field disposed in the path of movement of said conveyor and web for propelling particles from the web upwardly to said adhesive surface, said conveyor and web extending in proximity to each other beyond the point of electrical deposition whereby any surplus particles tending to remain on the web will be returned to said conveyor under the influence of gravity immediately after the web has passed from the electrical field.

28. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above another having opposing faces of substantial area, means for applying a potential difference to the upper and lower electrodes, means for supporting an adhesive coated web between said electrodes and with an adhesive coated surface downward, and means for supplying granular particles between said web and the lower of said electrodes, said apparatus being adapted to electrostatically project granular material against the downwardly facing adhesive surface of the web.

29. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above another having opposing faces of substantial area, means for applying a potential difference to the upper and lower electrodes, means for passing an adhesive coated web between said electrodes and with an adhesive coated surface downward, and means for supplying granular particles between said web and the lower of said electrodes, said apparatus being adapted to electrostatically project granular material against the downwardly facing adhesive surface of the web.

30. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a high electrical potential difference to the upper and lower electrodes, means for passing an adhesive coated web between said electrodes with the adhesive coated surface downward, a feed belt passing over the lower electrode for carrying the granular material into the electrostatic field between the electrodes and means for supplying granular material to the feed belt, said apparatus being adapted to electrostatically project the granular material from the feed belt upwardly against the downwardly facing adhesive coated surface of the web.

31. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a high electrical potential difference to the upper and lower electrodes, means for passing an adhesive coated web between said electrodes with the adhesive coated surface downward, a feed belt passing over the lower electrode for carrying the granular material into the electrostatic field between the electrodes, means for supplying granular material to the feed belt and additional means for controlling the quantity of granular material supplied to said feed belt, said apparatus being adapted to electrostatically project the granular material from the feed belt upwardly against the downwardly facing adhesive surface of the web.

32. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a high potential difference between said upper and lower electrodes, means for passing an adhesively coated web between said electrodes with the adhesively coated surface downward, a feed belt passing over the lower of said electrodes for carrying the granular particles into the electrostatic field between the electrodes, means for distributing said particles as a layer over said feed belt, said apparatus being adapted to electrostatically project the granular material upwardly as a shower with the particles spaced apart and free from each other.

33. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a high electrical potential difference between said upper and lower electrodes, means for passing an adhesively coated web between said electrodes with the adhesive coated surface downward, a feed belt for carrying the granular particles into the electrostatic field between the web and the lower of said electrodes, said apparatus being adapted to electrostatically project the granular particles upwardly through a substantially quiescent at-

mosphere against the downwardly facing adhesive coated surface of the web.

34. In apparatus for making a new sandpaper or emery cloth, the combination comprising a hopper for abrasive particles, an opening in said hopper to feed a thin layer of the abrasive particles out of said hopper, an endless belt adapted to pick up the thin layer of abrasive particles, means beneath said belt adapted to move the abrasive particles in relation to said belt, means for carrying the flexible backing sheet of the sandpaper or the like with a coat of adhesive over the surface thereof exposed at a point adjacent said means beneath said belt and said endless belt and in adjustable relationship to each other, whereby the abrasive particles carried by said belt are moved by said means beneath said belt to the surface of the adhesive on the flexible sheet automatically to coat the surface of the sheet with the abrasive particles standing out individually one from the other.

35. In apparatus for making a new sandpaper, the combination comprising a hopper for abrasive particles, an opening from said hopper to feed a thin layer of abrasive particles out of said hopper, an endless belt adapted to pick up the thin layer of abrasive particles, a blower beneath said endless belt adapted to blow the abrasive particles off said belt, means for adjustably disposing said endless belt and a flexible backing sheet of the sandpaper or the like with a coat of adhesive over the surface thereof in relation to each other adjacent said blower whereby the abrasive particles carried by said belt are blown by said blower into the surface of the adhesive on the flexible sheet automatically to coat the surface of the sheet with the abrasive particles standing out individually one from the other.

36. Apparatus for making sandpaper including an endless belt carrier, a hopper and spreader for abrasive particles adapted to spread abrasive particles onto said endless belt carrier as it travels past said hopper and means for moving the abrasive particles off said belt against an adhesive surface of a sheet in position to permit the surplus abrasive particles to fall away from the same and including means for receiving said excess particles and conducting the same away from the means for moving the same against the adhesive surface.

37. In a device for making abrasive material including, a carrier, a hopper for distributing abrasive particles onto said carrier, means for operating said carrier, means for shooting the abrasive off of said carrier, and means for extending the material having an adhesive surface at a point adjacent said means for shooting the abrasive in adjustable relationship to each other to cause the abrasive particles to adhere to the material and form the abrasive material.

38. An apparatus of the class described comprising a horizontally moving conveyor for abrasive particles, means for moving an adhesive coated web horizontally and parallel to said conveyor above the same so as to expose its adhesive surface with relation to particles on said conveyor, and means disposed in the path of movement of said conveyor and web for propelling particles from the conveyor upwardly to said adhesive surface.

39. An apparatus of the class described comprising a horizontally moving conveyor for abrasive particles, means for moving an adhesive coated web horizontally and parallel to said conveyor above the same so as to expose its adhesive surface with relation to particles on said conveyor, and means disposed in the path of movement of said conveyor and web for propelling particles from the conveyor upwardly to said adhesive surface, said conveyor and web extending in proximity to each other beyond the point of said means whereby any surplus particles tending to remain on the web will be returned to said conveyor under the influence of gravity immediately after the web has passed from the said means.

40. An apparatus for making sand paper including, an endless belt carrier, a hopper and spreader for abrasive particles adapted to spread abrasive particles onto said endless belt as it travels past said hopper, and electrical means for shooting the abrasive particles off of said belt against an adhesive surface on the paper adapted to make the abrading surface of the said paper.

41. The method of manufacturing granular coated webs which comprises applying a layer of adhesive to a side of a continuously moving web, moving said web in such a manner that the adhesive coated side is positioned downward, supplying irregularly shaped granular particles to a feed belt positioned beneath said web and moving in a direction substantially parallel therewith, passing said web through an electrical field including at least one electrode, controlling the spacing between said web and said feed belt, and projecting the granular particles from said belt onto the adhesive coated web during passage of the same through the electrical field.

42. The method of manufacturing granular coated webs which comprises applying a layer of adhesive to a side of a continuously moving web, moving said web in such a manner that the adhesive coated side is positioned downward, supplying irregularly shaped granular particles to a feed belt positioned beneath said web and moving in a direction substantially parallel therewith, passing said web and belt through an electrical field and projecting the granular particles from said belt onto the adhesive coated web while passing through said field.

43. The method of manufacturing granular coated webs which comprises applying a layer of adhesive to a side of a continuously moving web, moving said web in such a manner that the adhesive coated side is positioned downward, supplying irregularly shaped granular particles to a feed belt positioned beneath said web and moving in a direction substantially parallel therewith, passing said web and belt through an electrical field having an electrode disposed above said web, and projecting the granular particles by electrical attraction from said belt onto the adhesive coated web while passing through said field.

44. The method of manufacturing granular coated webs which comprises applying a layer of adhesive to a side of a continuously moving web, moving said web in such a manner that the adhesive coated side is positioned downward, supplying irregularly shaped granular particles to a feed belt positioned beneath said web and moving in a direction substantially parallel therewith, passing said web and belt through an electrical field having an electrode disposed above said web and another below said belt, and projecting the granular particles by electrical attraction from said belt onto the adhesive coated web while passing through said field.

45. A coating machine comprising a receptacle for abrasive particles to be applied as a coating

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to a carrier including means to guide said carrier, means to discharge the particles from the receptacle to fall by gravity and to spread the same preliminarily, means in the path of the particles falling from the receptacle to feed them in a distributed condition toward said carrier and means to vibrate said last mentioned means, whereby the particles are further distributed and applied to said carrier.

46. Apparatus for adhesively affixing elongated or attenuated materials upon a surface comprising opposed electrode means insulated from each other, one of said electrodes being foraminous and serving to distribute said materials, means for establishing an electric field between said electrodes, means for feeding between said electrodes a web, the surface of which is to be coated with said materials and means for introducing elongated or attenuated materials to be directed into the electric field between said electrodes and cooperating with the openings in said foraminous electrode to feed the materials into the field in a distributed condition.

47. Apparatus in accordance with claim 46 in which there is included means for conducting an adhesively coated web between said electrodes, with the adhesive coated surface downwardly faced towards the foraminous electrode.

48. In a deposition apparatus, in combination, means for supporting a backing, means for applying an adhesive thereto and facing the adhesively coated backing downward, means below and spaced from said backing for supplying comminuted material susceptible of carrying an electrical charge for causing movement thereof, and means including electrically charged elements below and above said backing for propelling said material upward onto the backing to adhesively unite the same to said backing.

49. In a deposition apparatus in accordance with claim 48, the combination wherein said means for supporting the backing includes means for facing the adhesively coated surface thereof downwardly during the time said electrically charged elements are effectively operating upon the material which is propelled upwardly to the said adhesively coated surface of said backing.

50. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a potential difference to the upper and lower electrodes, means for supporting an adhesive coated web between said electrodes with an adhesive coated surface thereof downward, means for supplying granular particles between said web and the lower of said electrodes, said apparatus being adapted to electrically project granular material against the downwardly facing adhesive surface of the web, said electrodes being plates, which achieve orientation of a substantial number of the particles substantially normal to the plates and the web which is being coated between them.

51. Apparatus for the manufacture of granular coated webs comprising electrodes arranged one above the other, means for applying a potential difference to the upper and lower electrodes, means for supporting an adhesive coated web between said electrodes with an adhesive coated surface thereof downward, means for supplying granular particles between said web and the lower of said electrodes, said apparatus being adapted to electrically project granular material against the downwardly facing adhesive surface of the web, one of said electrodes being a plate.

52. An apparatus for forming bonded granular articles wherein elongated granular materials are adhesively combined upon a web for said materials comprising electrodes arranged to be spaced apart in relation to the web, means for applying a potential difference to said electrodes and means for supplying an adhesive to form a bond for said materials to said web and means for introducing elongated granular materials for said web between said electrodes, said electrodes being spaced apart and insulated from each other by the dielectric strength of the air and including the dielectric strength of insulating material applied to at least one of said electrodes which, by reason of the potential difference imposed upon said electrodes, maintains an electrostatic field adapted to electrostatically orient the elongated granular particles so that their longest dimensions lie in a predetermined direction in respect of said web.

53. Apparatus for the manufacture of granular coated webs comprising an electrode arranged to be positioned above the web to be coated and spaced apart from an electrode arranged to be positioned below the web, means for applying a potential difference to said electrodes, means for supporting an adhesive coated web between said electrodes and with the adhesively coated surface faced downwardly, and means for supplying granular particles between said web and the lower of said electrodes, said electrodes being spaced apart and insulated from each other by the dielectric strength of the air and the dielectric strength of insulating material applied to at least one of said electrodes, the potential difference imposed upon said electrodes and the dielectric between said electrodes maintaining an electrostatic field between said electrodes, said apparatus being adapted to electrostatically project granular particles against the downwardly facing adhesive surface of the web.

54. Apparatus for the manufacture of granular coated webs comprising a plate electrode arranged to be positioned above the web to be coated and spaced apart from a plate electrode arranged to be positioned below the web, means for applying a potential difference to said plates, means for supporting an adhesively coated web between said plates and with the adhesively coated surface faced downwardly, means for supplying granular particles between said web and the lower of said paltes, said plates being spaced apart and lying in the direction of travel of the web, and insulated from each other, the arrangement of the plates in relation to the potential difference imposed on said plates and the dielectric between the plates serving to maintain a strong electrostatic field, said apparatus being adapted electrostatically to orient and project granular particles against the downwardly facing adhesive surface of the web.

55. In an apparatus for coating particles of material upon a backing the combination comprising a carrier for particles of material deposited thereon, means propelling said particles upwardly against the force of gravity from the surface of the carrier upon which said particles have been deposited to a surface of said backing coated with an adhesive, means acting upon the particles deposited upon the carrier for distributing said particles of material, subsequent to deposition thereof on said carrier surface, to spread the same evenly on said carrier surface prior to the propulsion thereof to said adhesive coated surface of said backing.

56. Apparatus in accordance with claim 55

wherein the means for distributing the particles comprises electrically energized elements creating an electrostatic field which disperses the particles in relation to each other.

57. In an apparatus for coating particles of material upon a backing the combination comprising a carrier for particles deposited thereon, means propelling said particles upwardly against the force of gravity from the surface of the carrier upon which said particles have been deposited to a surface of said backing coated with the adhesive, means acting upon the particles deposited upon the carrier for distributing said particles of material subsequent to the deposition thereof on said carrier surface to spread the same on said surface prior to the propulsion thereof to said adhesive coated surface of said backing, said distributing means comprising mechanical means acting upon the particles to form a substantially uniform layer.

58. In an apparatus of the character described, means for supporting a backing, means for applying an adhesive thereto and means below and moving synchronously with said backing for feeding a pulverulent material, and means for applying said material to said backing.

59. In an apparatus of the character described, means for supporting a backing, means for applying an adhesive thereto, and means below said backing for feeding a pulverulent material, and means acting electrically upon said pulverulent material for applying it to said adhesive coated backing.

60. In an apparatus of the character described, means for supporting a backing, means for applying an adhesive thereto, and means below said backing for feeding a pulverulent material, and electrostatic means for applying said material to said backing.

61. The method of applying elongated particles of material to an adhesive coated surface of a backing which includes the steps of depositing said particles upon a moving surface, passing said moving surface through an electrostatic field generated by two vertically opposed electrodes wherein the particles are charged and successively repelled from the surface and deflected back by the upper electrode to the surface whereby said particles are distributed thereon to spread the same and form a uniform layer with the particles thereof evenly distributed, bringing said adhesive coated surface of said backing into spaced relationship to said moving surface and applying an upwardly directed force to the uniform layer to propel said particles against the force of gravity and to transfer the particles from said moving surface and to embed them endwise in the adhesive coating on said backing surface.

63. The method of coating a continuously moving adhesively coated backing with elongated particles of matter comprising forming the particles into a layer, conducting the layer through an electrostatic field generated by two vertically opposed electrodes, with the lines of force substantially normal to the layer where the particles are charged and successively repelled from the layer and deflected by the upper electrode evenly back to the layer to disperse and to distribute the particles in the layer, positioning the adhesively coated backing in a second electrostatic field which applies an upwardly directed force to the dispersed layer to propel the particles in a direction resisting the normal force of gravity onto the adhesive coated surface of the backing and arranging them on end by conducting the dispersed layer into the second field adjacent the adhesive coated side of the backing.

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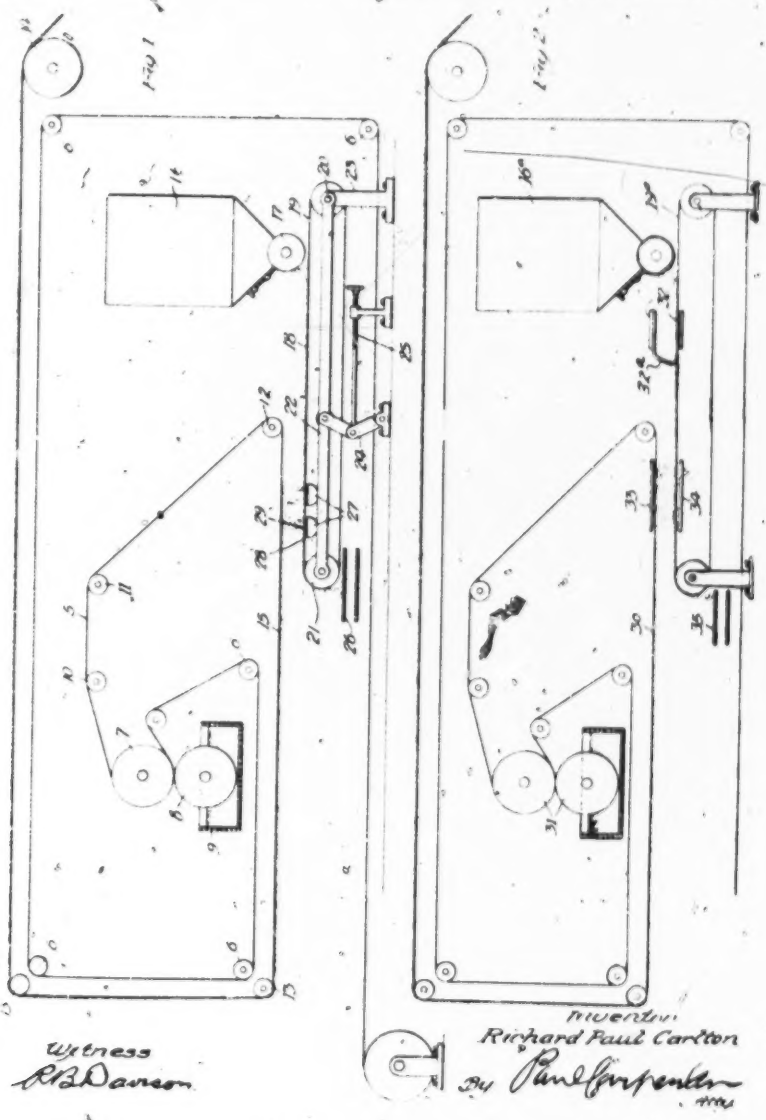
May 4, 1943. R. P. CARLTON 2,318,571

MANUFACTURE OF ABRASIVES

Filed Dec. 22, 1933 7 Sheets-Sheet 1



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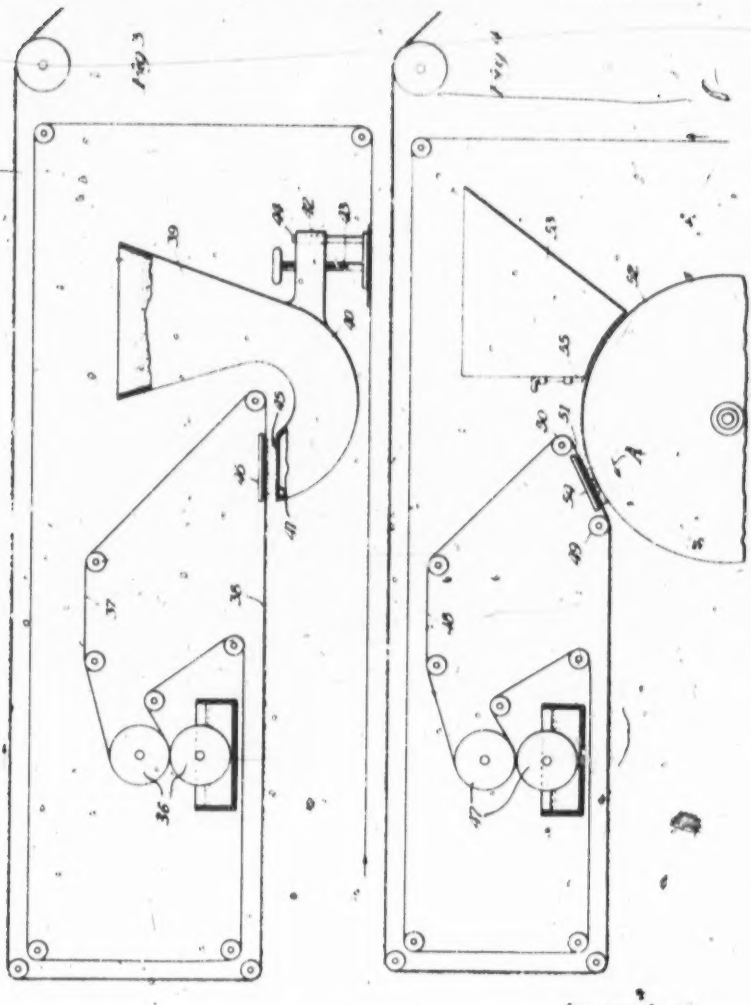
MANUFACTURE OF ABRASIVES

Filed Dec. 22, 1933 7 Sheets-Sheet 2



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MANUFACTURE OF ABRASIVES

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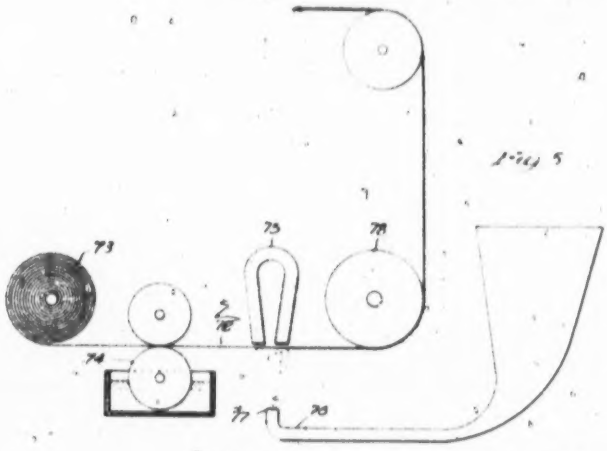

Fig 5

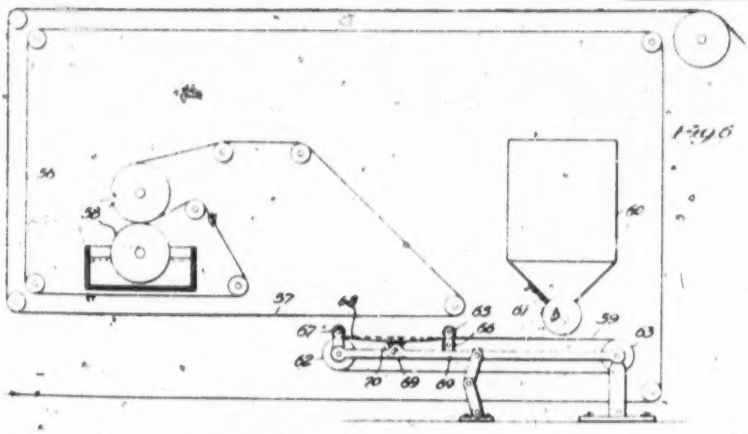

Fig 6

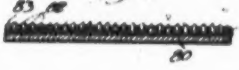

Fig 7

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MANUFACTURE OF ABRASIVES

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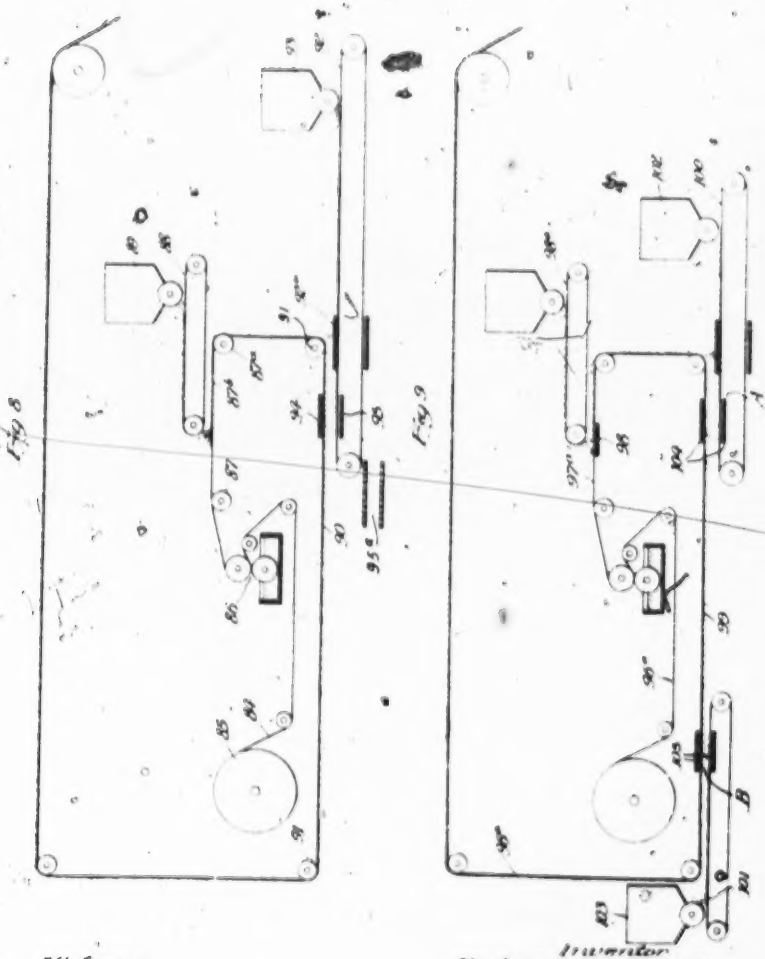

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MANUFACTURE OF ABRASIVES

Filed Dec. 22, 1933 7 Sheets-Sheet 5

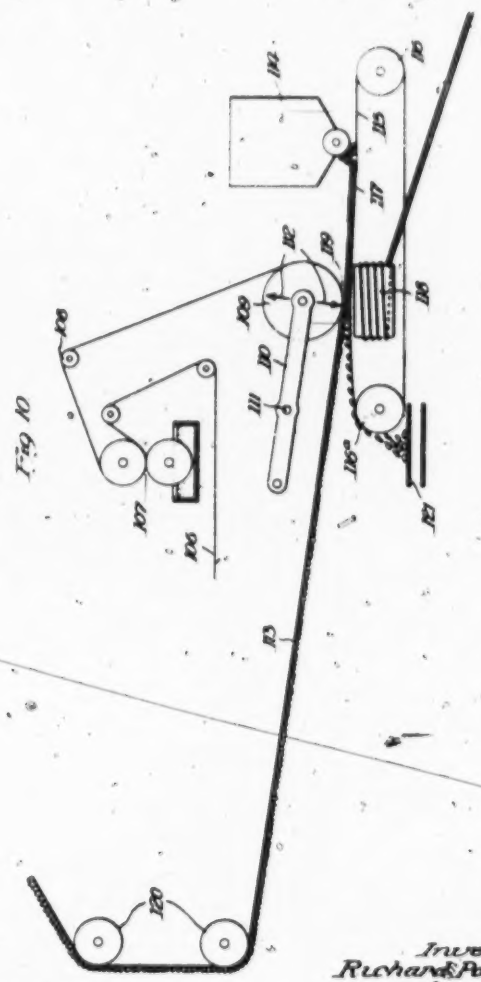

Fig 10

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MANUFACTURE OF ABRASIVES

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Fig 11

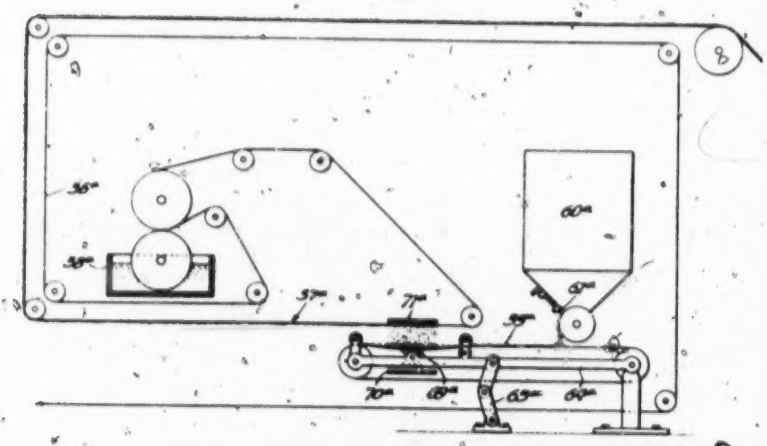
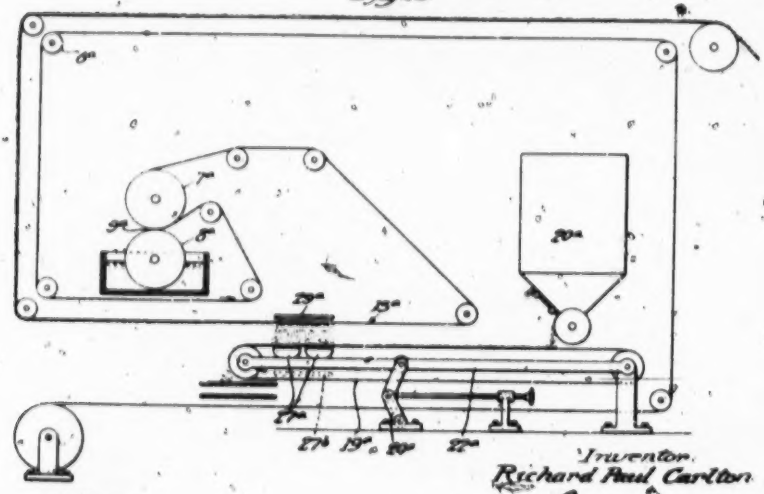


Fig 12



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[fol. 606]

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MANUFACTURE OF ABRASIVES

Filed Dec. 22, 1935 7 Sheets-Sheet 7

Fig. 13

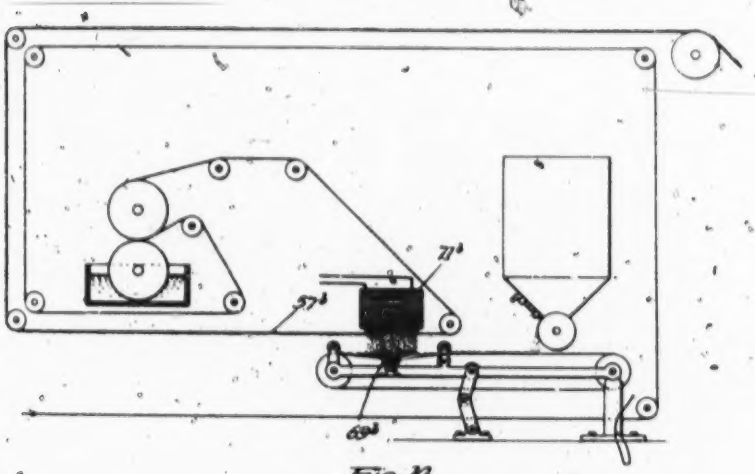
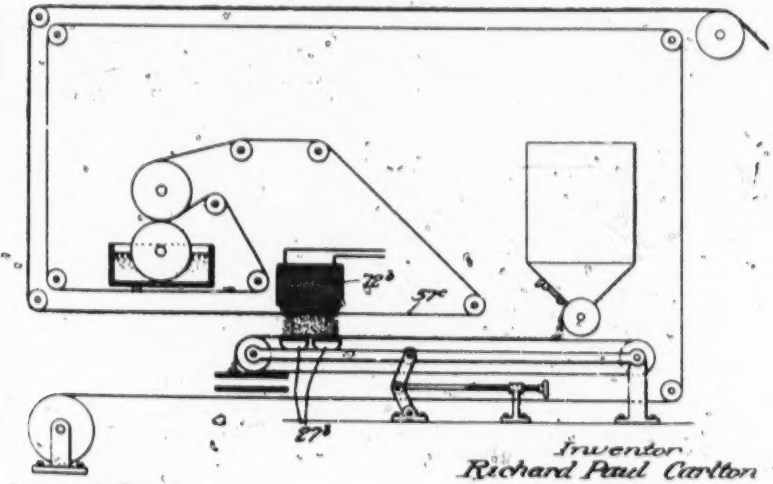


Fig. 14



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[fol. 607]

Patented May 4, 1943

2,318,571

UNITED STATES PATENT OFFICE

2,318,571

MANUFACTURE OF ABRASIVES

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Application December 23, 1933, Serial No. 703,559

7 Claims. (Cl. 91—18)

This invention relates in general to coated articles and to the art of coating, and more particularly to an improved apparatus for applying pulverulent coatings to suitably adhesively coated surfaces, and while the invention finds particular utility in the art of making flexible abrasives, and is, therefore, described and illustrated for this purpose, it finds a wide field of utility for analogous purposes.

This application is a continuation-in-part of my applications S. N. 422,065 and 662,319, filed January 20, 1930 and March 23, 1933, respectively.

It is well known that in the art of making sandpaper, emery paper or cloth and similar abrasive articles, a flexible or in some cases, a rigid, backing of paper, cloth, wood or the like, is employed, to which is applied a coating of an adhesive substance, such as animal or vegetable glue, or where a waterproof article is desired, the backing may be coated with any of the now well known waterproof adhesives for this purpose, and while the coating is still wet or unset, a suitable, abrasive material such as garnet, corundum, sand, or the like is applied thereto. The grains of abrasive substances are usually applied by gravity upon the upper adhesive coated surface of the backing and they lie in the adhesive material in haphazard fashion due to the elongated nature of the abrasive particles, and, in a large degree, the facets or cutting edges of the individual grains or grits often lie flat upon or are embedded in the adhesive coating in such a manner that in some instances their best cutting edges never come into contact with the work, or, at best, are brought inefficiently into contact therewith. The invention here has as one of its objects to measurably increase the number of grits whose longer or greater dimensions are in a plane perpendicular to the surface of the backing, thereby to present more efficiently the cutting edges to the work, and increase the cutting ability and life of the abrasive article.

It will be understood that in ordinarily depositing mineral, that is, pulverulent abrasive material solely under the force of gravity onto a backing, it acquires a velocity due to the action of gravity. As the grits pass through the intervening air space, there will be caused some change in their positions en route to the sheet or backing, but ordinarily neither the velocity given to the grits or the effect of the air on them is sufficient to cause them to become aligned so as to assume positions substantially perpendicular to the backing. It is, therefore, necessary that independent force be applied to the grits, and I have found that by passing the grits through a static field of electric energy or of electro-magnetic energy or by mechanically imparting this force to the grits, a much greater number of the individual particles will assume erect positions on the backing, which will enhance its cutting ability. As will later appear, my invention, in its several forms, is capable of application for operation in conjunction with gravity methods of applying the grit, inasmuch as under certain conditions, and for some purposes, it is desirable to employ both gravity and one of the forms of my invention in conjunction in order to attain a desired form of abrasive article.

In carrying out this invention, I find it desirable to employ a conveyor for conducting the mineral at rest relative to the conveyor by relatively slow speed to a point adjacent to which the independent force is applied for projecting the particles of grit onto the backing. I find that by then applying this independent force, be it mechanical or electrostatic or electromagnetic, I am able to impart a high velocity to the particle so that any force of gravity acting on the particle, whether in the same direction, in a counter direction, or in a direction angularly to that at which the force is applied, will be relatively small compared to this force applied. It is possible with the present invention to apply the force directly counter to gravity, that is, by bringing the grits beneath the backing or by applying the force in some other direction as long as the force of gravity and the effect of air is reduced below a point which will interfere with the result desired, namely, the projection of the grits with their longitudinal dimensions ultimately perpendicular, or substantially so, with respect to the backing.

This invention further includes as objects and advantages thereof, the provision of an improved apparatus for manufacturing abrasive articles; the provision of an improved apparatus for applying pulverulent material to one surface of a backing irrespective of the force of gravity, that is, against the normal tendency of the force of gravity; the provision of an apparatus for propelling a pulverulent material, such as a grit or an abrasive grain, against an adhesive coated surface; the provision of an apparatus for the purpose set forth and including electrically operated means for acting on an abrasive grain or pulverulent material and causing it to advance onto the adhesive coated backing irrespective of the force of gravity; the provision of an improved apparatus for causing the particles of

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pulverulent material to impinge upon and assume a position in the adhesive coated surface substantially normal or perpendicular to the surface of the backing; the provision of an improved apparatus for propelling a pulverulent material onto a moving sheet in a direction transversely to the plane of movement thereof and in a direction substantially counter to gravity; the provision of an improved apparatus for making abrasive articles, such as sandpaper and the like, which includes the application of a grit to the under side of the backing; the provision of an improved apparatus which includes means for feeding and applying a pulverulent material counter to the force of gravity and simultaneously with movement of the backing; the provision of an improved means for moving a web of paper and applying an adhesive thereto and including means arranged below and for operating synchronously with for applying a pulverulent material to the under side of said moving backing; and the provision of an apparatus of the character described wherein impelled electrostatic or electromagnetic means may be employed, acting on the abrasive material and causing it to move at an accelerated speed toward the sheet so as to cause it to impinge thereon in the adhesive coating and thereby present the cutting edges of the abrasive grits away from the surface of the backing and thus increase the cutting ability and life of the abrasive article.

The apparatus of this invention includes a number of alternative forms for mechanically or electrically carrying out the steps of the process and to this end is provided an improved pneumatic means and improved vibrator structure for mechanically propelling the pulverulent material and improved electrostatic and/or electromagnetic structure for acting on the mineral and causing it to move in a cloud toward the adhesive coated surface of the moving web or backing.

With the foregoing and such other objects and advantages as may appear or be pointed out as this description proceeds are attained in the structures illustrated in the accompanying drawings in which:

Figure 1 is a schematic view illustrating one form of apparatus for carrying out the process of this invention;

Figure 2 is a view similar to Figure 1 of an alternative form of the invention;

Figures 3, 4 and 5 are further alternative forms of the invention which include the electrical feature;

Figure 6 is a further alternative form of the apparatus of this invention for employing vibrating means;

Figure 7 is an enlarged schematic view illustrating a portion of an abrasive article made in accordance with this invention;

Figures 8 and 9 are additional alternative forms of apparatus for carrying out further steps of the process of this invention; and

Figure 10 is a further alternative form of apparatus for carrying out one of the methods of this invention;

Figures 11 and 12 are further alternative forms for carrying out additional methods of the present invention; and

Figures 13 and 14 are further alternative forms for carrying out additional methods of the present invention.

The operation of the apparatus includes as steps thereof the feeding of a web or strip of paper or other fabric at a predetermined rate of speed, applying an adhesive substance to the under side of the sheet, or applying the adhesive coating to one side and then moving the sheet with the coated side out, and simultaneously with the movement of the coated sheet causing a grit or abrasive material to be applied to this side. The sheet or web of paper may be moved so that the adhesive coated side is either presented downwardly or at any angle thereto. The movement of the abrasive grains onto the under side of the backing is done irrespective of the force of gravity and, in fact, directly counter to gravity, and preferably done by imparting relatively high velocity to the abrasive material, thus causing it to impinge upon the adhesive coating. In view of the fact that the abrasive grains are projected through an intervening space from a suitable carrier on to the adhesive coated side irrespective of or counter to the force of gravity, the grains, which are usually somewhat elongated, will assume a position in transit so that the longer dimension thereof will take a position normal to the surface of the backing, thus causing the grains to "stand" on the surface rather than lie flat in greater percentage than when they are deposited by gravity. It is to be understood that this movement of the grains and deposition of them on the coated surface may be carried out in a number of ways, either by vibration, by an air blast, or by electrostatic or electromagnetic means, or both.

In the alternative forms of this apparatus later to be described, the operation of the apparatus involved includes combining a gravity deposition of mineral on the adhesively coated moving backing with the step of applying the grits irrespective of gravity, this being particularly useful in some of the heavier grits wherein it may be found that the force susceptible of application by an electrostatic or an electromagnetic means is not sufficiently active on the available area of the individual grits to cause an entirely satisfactory result or to move enough of the grits onto the sheet to attain the desired end. In this invention it may be required to apply some of the grit by gravity and later apply some of the grit by one of the methods of this invention or vice versa, but, in any event, the number of grits in the entire finished article which stand erect on the backing will be measurably increased over the ordinary methods heretofore employed for depositing grit on a backing for forming an abrasive article.

This invention produces a very satisfactory piece of sandpaper in which the cutting ability is measurably increased and by the deposition of the grains of sand or grit irrespective of the force of gravity, it is possible to produce an orientation of the mineral as desired and to control the thickness of the abrasive coating much more readily than where gravity alone is relied upon or employed for depositing the grains on the sheet.

The apparatus of this invention may take one of the forms shown in the drawings and in the form of the invention shown in Figure 1, air pressure is resorted to for producing the mineral cloud and for projecting the mineral onto the moving web.

Referring now more particularly to Figure 1, the flexible backing 5 of paper or cloth or other fabric is trained or fed over a series of rollers 6, 6, and over one of a pair of the squeeze rollers indicated at 7, the other roller 8 of said pair being in contact with an adhesive material con-

tained in a tray or tank 9 by which an adhesive coating is applied to one side of the moving web. After receiving the adhesive coating, the web 8 is trained over rollers 10 and 11 and is brought back over a roller 12 so that the adhesive coated surface of said web is presented downwardly. The web may then be trained over rollers 13, 13, and fed to a suction drum 14, whence it passes into festoons for drying.

The mineral is supplied from a hopper 15 and a conventional outlet 17 which feeds a layer 18 of mineral to a moving conveyor 19. This conveyor 19 is preferably pirous and passes over the feeding rollers 20 and 21 and is adapted to move at a suitable rate of speed to supply a sufficient quantity of abrasive grain. In some cases, it has been found advantageous to move the conveyor at a speed substantially the same rate of speed as the web 18, although these speeds are, of course, variable. The rollers 20 and 21 are mounted in the ends of a suitable frame 22 and this frame may be raised and lowered so as to vary the distance between mineral conveyor 19 and the moving web 18. This frame 22 may be supported fixedly at one end, as indicated at 23, and the other end may be raised and lowered by a toggle arrangement 24 activated by a threaded rod 25. Below the conveyor 19 and at the movable end thereof, that is, adjacent to the web 18, there is provided a second conveyor 26 which serves to conduct away excess mineral which flows over the end of the conveyor 19 and which may be returned in any suitable manner to the mineral hopper,

Below the upper flight of the conveyor 19, there are provided two air troughs 27. These air troughs are provided with flat upper walls 28, having slots 29 therein, said slots extending across the width of conveyor 19 and the troughs themselves being connected to a suitable source of air under pressure.

These troughs form in effect elongated jets or nozzles and when so placed below the conveyor belt or frame 22, a small quantity of air is emitted at high velocity which passes through the porous belt or conveyor.

It will be understood that when a blast or blasts of air are delivered from the troughs 27, this blast of air passes through the porous conveyor 19 and blows the mineral from the conveyor against the under side of the flight 18 so that the mineral is caused to strike into the adhesive at a relatively high velocity and become impinged therein. Owing to the projecting of the mineral in this manner through the intervening air space, the individual particles of grit or abrasive material are caused to assume a position parallel to their trajectory, that is, with their longer dimension perpendicular to the surface of the flight 18. In view of the fact that most of the particles of mineral are somewhat elongated, due to the manner of production of the same, they will naturally assume this position in movement from the conveyor 19 to the adhesive coated surface of the backing. As they arrive at the adhesive material they impinge themselves therein and will thus stand erect in the adhesive, thus forming a sharper contour for abrasive purposes. By varying the rate of speed of the moving backing relatively to the speed of the conveyor and by varying the distance between the conveyor and the backing and the velocity of the air stream, and by increasing or reducing the number of such jets and the quantity of adhesive applied, any reasonable desired thickness of grit layer may be produced during the process and without stopping the apparatus. It will be understood that the excess mineral carried by the conveyor may be dumped into the conveyor 26 and returned by any suitable means to the hopper 15.

Referring now to Figure 2, there is provided the same general arrangement of moving backing, having the flight 30 adhesively coated from the squeeze rollers 31.

Below the flight 30 there is provided a mineral feeding conveyor 19a, receiving pulverulent material from the hopper 15a.

The conveyor 19a is mounted for movement toward and away from the flight 30 similar to the conveyor 19 and, therefore, this structure has not been shown in Figure 2.

As the mineral flows from the hopper 15a it does not always assume a smooth or even distribution on the conveyor 19A, and, therefore, it may be desirable to provide a pair of charged electrodes 32, one arranged above and one below the conveyor 19a, for the purpose of spreading the mineral evenly on the conveyor belt. The conveyor 19a in this instance may be non-porous.

When charged electrodes are put in this position they act in principle the same as the charged electrodes used for coating the mineral on the backing. An electrical charge or difference of potential is set up between the electrodes 32. The voltage or difference in potential between these electrodes is maintained great enough to produce a strong static field, but not so great as to break down the insulation between the plates, which insulation may be the dielectric strength of the air or the dielectric strength of the air plus the dielectric strength of any insulating material which may be used to wrap the electrodes.

As the mineral on the conveyor enters the static field between the plates the mineral particles take on the charge of the lower plate, and are repelled to the upper plate where they lose their charge and take on the opposite charge of the upper plate. At this point they are repelled to the lower plate. Since new mineral is being conveyed by the conveyor into the field continuously the static fields soon become supersaturated with mineral particles, and an equilibrium is reached where as many particles are thrown out of the static field as are brought in by the conveyor. By having a down-turned end 32a of the upper electrode the mineral particles that are thrown out of the static field are deflected evenly on the conveyor belt so that a smooth coating of abrasive grit is first placed on the conveyor.

The use of a static field for getting a smooth coating of mineral on the conveyor belt is not necessary to the invention but is an additional means of obtaining evenly distributed abrasive coatings, and is also a means for avoiding the use of any excess mineral on the conveyor. When the mineral is evenly coated on the conveyor at the time it is being coated, streaks, thin spots, etc., in the finished product are reduced.

At the same approximate point at which troughs 27 are provided in Figure 1 there are here provided electrically charged electrodes 33 and 34, the electrode 34 being located below the upper flight of the conveyor belt 19a and electrode 33 being disposed above the flight 30 of the backing. A sufficient difference of potential is maintained at electrodes 33 and 34 to produce a strong static field, similarly to that referred to above. This

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static field moves the mineral from the belt 18a to the underside, which is the adhesive coated surface of the flight 38.

As the mineral enters the static field between the electrodes 33 and 34 it becomes charged with the charge of the lower plate, and is here propelled to the upper plate 33.

It will be observed that in this method of coating the mineral is applied by a force other than gravity. In all other methods of coating sandpaper, known to me, the velocity of the particle is either in whole or in part given to it by the force of gravity. In the case of this electrostatic coating the particles are oriented in the static field so that there is a tendency for the long dimension of the mineral to be perpendicular to the electrode plates, and also perpendicular to the web 36, which is being coated. The finished sandpaper product, therefore, contains a substantial percentage of the particles of mineral standing on end rather than lying flat, thereby increasing the cutting properties of the abrasive article.

Excess mineral is dumped onto the conveyor 36, whence it may be returned to the hopper 18a.

Referring now to the alternative form of the invention shown in Figure 3, there are provided the squeeze rollers 36 which apply adhesive to one surface of the moving paper web 37 and the adhesive coated surface thereof is presented downwardly in the flight 38.

In this instance there is provided a hopper 39, having a curved outlet spout 40 whose outlet 41 is presented below the moving web 38. The hopper may be provided with a bracket 42 whereby to receive a threaded member 43, said bracket engaging a guide post 44. In this manner, the hopper may be raised or lowered so as to vary the distance of the outlet 41 from the flight 38 of the backing. A suitable screen 45 may or may not be provided over the outlet so as to control the distribution of the mineral contained in the hopper. In this instance, the mineral flows by gravity to the outlet 41, but does not pass from the outlet to the adhesive coated backing by gravity, but under the effect of the static charge established between the electrode 46 and the hopper or the screen 45 of said hopper.

The operation of the invention here is much like that of Figure 2, the screen 45 serving the purpose of distributing the mineral and at the same time preventing the large body of mineral in the hopper from forcing it against the coated surface of the backing.

Referring now to the form of the invention shown in Figure 4, there is provided the adhesive coating rollers 47, applying an adhesive coating to one surface of the moving web 48. This web 48 is trained over rollers 49 and 50 so that flight 51 thereof between said rollers is presented in a plane tangential to the surface of a conveyor drum 52 whose lineal velocity is sufficient to furnish the required amount of mineral. This drum is fed from a hopper 53 and forms one electrode of the electrostatic system. The other electrode is indicated a 54 and is disposed above the flight 51. As mineral issues from the gate 55 of the hopper, the drum rotating in the direction of the arrow a, the mineral is carried to a point adjacent to the flight 51 whereupon the electrostatic charge set up between the drum 52 and the electrode 54 will cause a projection of the mineral from the drum onto the coated surface of the flight 51.

Referring now to the alternative form of the invention shown in Figure 5, there is employed here electromagnetic means or a permanent magnet means for moving the grits toward the adhesively coated web. The adhesively coated web is shown at 72 and is fed from a roll 73 over an adhesive coating roller 74. The horizontal flight of the web 72 passes beneath magnet 76 which may be either an electromagnet upon which a variable voltage may be imposed or a permanent magnet.

Immediately below the magnet 76 and the flight 77 of the web, there is provided a source of supply for the mineral, that is, the abrasive material, indicated at 78. This source includes an outlet 77, and the distance between the outlet 77 and the moving web 72 may be varied as desired, or the intensity of the electromagnet, where one is employed, may be varied for changing the thickness of the abrasive coating. The web passes over an idler 78 whence it is fed to festoons not shown.

Referring now to the form of the invention shown in Figure 6, the moving web 86 is trained over a series of rollers similar to the arrangement shown in Figures 1 and 2 so that a horizontal flight 87 of the paper backing is provided, having an adhesive coating on the under side thereof. Squeeze rollers 88 engage the paper backing for applying an adhesive thereto.

In this form of the invention, a mechanical vibrating means is provided which serves to propel the mineral, that is, the grit, from the grit feeding conveyor 89, which latter receives mineral from the hopper 90, having a gate 91. The conveyor 89 is trained over rollers 92 and 93 mounted in a suitable frame 94, which latter may be mounted for adjustment toward and away from the flight 87 similarly to the conveyor 19 of Figure 1. The conveyor 89 extends below and is separated from the flight 87 of the paper web and travels at substantially the same speed as the paper web.

The conveyor 89 passes between sets of pinch rollers, one above and one below the upper flight of the conveyor 89, as indicated by 95 and 96, and also beneath a pinch roller 97 which bears on the roller 92. The pinch rollers 95 and 96 tend to distribute the mineral evenly over the surface of the conveyor and are so spaced from the roller 92 and 97 that the portion of the belt 89 between the rollers 95 and 96, and 92 and 97 is permitted to lie slack, whereas the remaining part of the conveyor is substantially taut. This arrangement tends to limit the vibration of the conveyor belt to the zone of application of the mineral to the paper backing, as indicated at 98.

Beneath the portion 99 of the belt 89, there is provided a revolving batter 99 operating on a shaft carried in suitable bearings in the frame 94 and provided with a plurality of radial arms 79 which upon rotation rigidly strike the under side of the portion 99 of the belt, thus throwing or projecting the mineral content thereof against the under side of the adhesive coated paper backing, much in the manner in which the air stream blows the mineral or grit against the paper backing as shown in Figure 1. The batter 99 may be driven in any desired manner from a separate source of power or may be connected suitably with the rollers driving the belt 89, but geared to operate at a greater rate of speed. The rollers 95 and 96 and the roller 97 are separately driven from the belt 89 so as to produce the tautness in the belt, except the flight of the belt indicated at 98.

In Figure 7, there is illustrated an article made in accordance with the present invention. The backing is shown at 80, to which an adhesive coating 81 has been applied, and the grits, greatly enlarged, are indicated at 82 and it is noted that they stand on end in the adhesive coating, thus causing their sharper edges to project beyond the upper or outer surface of the coating, thereby enhancing the cutting ability and increasing the life of the abrasive article. While the article shown in Figure 7 is purely schematic, it will be understood that the mineral actually does take a position substantially normal to the backing and, while all of the grits may not take this position, a large number of the same do and the cutting qualities of the abrasive article are thus greatly increased. Furthermore, by so disposing the grits, it permits of the application of an additional sizing coat or coats to the back and to the fronts or cutting face of the abrasive material without completely burying the grits and as a thicker coat of adhesive may thus be employed on the cutting face of the abrasive material, the engagement of the adhesive material with the abrasive material is greatly enhanced, thus further tending to increase the life of the abrasive article. Such a sizing coat is indicated at 83.

As previously pointed out where the electrostatic or electromagnetic methods are resorted to in some of the coarser grades of abrasive devices made, it may be found that the electrostatic or magnetic field into which the particles are conducted may not exert on each individual particle sufficient force to cause proper orientation of the particles for the reason that the static effect is substantially proportional to the area of the particle and the coarser the particle, the smaller the area of effect per weight. Therefore, as larger grits or sizes of particles are employed, increased force is required to move the particle and for some purposes, insufficient increase in force results because of the reduced area per weight. Therefore, in such cases a form of the invention, as shown in Figure 8, may be resorted to wherein the mineral is applied to the adhesively coated backing in part by gravity and in part by electrostatic or electromagnetic means.

In view of the fact that the electrostatic and electromagnetic means may for some purposes be alternatively employed, I have illustrated in Figure 8 merely the electrostatic elements though it will be understood that the electromagnetic means of Figure 5 may be employed in the same manner.

Referring in detail to Figure 8, I have illustrated a web of paper 84 coming off a roll 85 and passing through an adhesive coating device illustrated in general at 86. The web 84 is thence trained over rollers 87, 87a, so that it has a substantially horizontal flight 87b, which receives grits in the desired amount from an ordinary conveyer 88, said conveyor receiving grits from the hopper 89. The web of paper thence is carried downwardly to a horizontal flight 90 by the provision of rollers 91, 91 and adjacent one end of this flight I provide the conveyor 92 receiving additional grits from the hopper 93, which may be adjustably mounted similar to the conveyors hereinabove described, said conveyer 92 passing beneath the flight 90 of the paper web. As the web passes over the rollers 87a and 91, a quantity of the mineral deposited from the conveyor 88 onto the web will drop off, and, for conveying away this excess mineral, I provide a transversely running conveyor 92a arranged between the flight 90 and the conveyor 92. Beneath the upper flight of the conveyor 92 and above the flight 90 of the web 84, I provide static electrodes 94 and 95, or may provide an electromagnet similar to that shown in Figure 5 which will cause grit coming from the hopper 93 to be applied counter to the force of gravity onto the under surface of the flight 90. A conveyor 95a may be employed for carrying off the excess mineral from the conveyor 92.

In the operation of this form of the invention, it will be understood that a desired proportion of mineral applied by gravity to that applied by force other than gravity may be determined by actual operation so that the desired quantity of the abrasive grits is properly applied to the paper web.

It may be necessary in some of the very coarse grains to additionally apply grit to the moving web and this may be done by providing an additional conveyor similar to that indicated at 92 and additional electrodes, or may be accomplished by additionally applying by gravity grits to the paper web just before it passes on to the festoons.

Figure 9 illustrates the alternative forms suggested in connection with Figure 8, that is, wherein electrostatic or electromagnetic means, or any other means counter to gravity, is employed for applying the grits and in Figure 9 the paper web is indicated at 96c having a horizontal flight 97a disposed below a conveyor 98a. In this instance, the grits are deposited from the conveyor 98a by gravity, and the orientation of the grits is assisted by a plate electrode 99. The paper web may then be carried in position so as to provide a horizontal flight 96 and an electrostatic or electromagnetic or other grit applying means for applying grit counter to gravity may be employed at one or more points as indicated at A and B, wherein the conveyors 100 and 101 convey grit from suitable hoppers 102 and 103, and electrodes 104, 104 and 105, 105 serve to apply the grit.

Referring now in detail to Figure 10, there is further illustrated there an apparatus for applying the grit to the adhesively coated backing by an electromagnetic means. In this form of the invention a moving web is provided indicated at 106, this web being a flexible strip of paper which is suitably adhesively coated by a mechanism indicated generally at 107.

The moving web thus adhesively coated is carried over a roller 108, thence over a roller 109, said roller 109 being mounted on a shaft carried in a bearing arm or arms 110 pivotally mounted at 111, whereby the roller 109 may be raised and lowered in the substantially vertical plane of the arrows 112, thus permitting the lower flight 113 of the paper web to be elevated or depressed, as the case may be.

Mineral is deposited from a hopper 114 on to a conveyor 115 trained over rollers 116 and 116a, the upper flight 117 of said conveyor passing beneath the rollers 108 and the moving web, and conveying mineral, that is, the grit, to a point adjacent to the roller 109.

Preferably immediately below the axis of the roller 109 and below the upper flight 117 of the conveyor 115 I provide an electro magnet 118 which is so mounted that its magnetic flux passes through the conveyor and causes the mineral particles to stand erect, as indicated at 119, as they move along with the upper flight of the conveyor. While the mineral particles are thus standing

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erit they come into contact with the adhesively coated side of the paper backing and are thus picked up by it and conveyed away, the backing being trained over rollers 120 and carried to the festoons similarly to the other forms of the invention. It will be observed that the angularity of the lower stretch 113 of the paper web is such that it lies upwardly to the conveyor 115. In this way the particles of grit adhering to the paper are not knocked down by other particles remaining on the conveyor, it being understood that the grit is fed somewhat in excess of the required amount so that an adequate amount will be deposited on the adhesively coated side of the backing. The excess mineral drops off the conveyor 117 and is carried to a collecting means by a conveyor 121.

It will be understood that the amount of mineral fed from the hopper, the strength of the electro magnet, that is, the strength of the flow current transferred and the position of adjustment of the roller 109 may all be properly correlated for obtaining the desired grade of finished article.

It may be desirable that a certain amount of pressure be exerted on the erect particles of mineral so as to cause them to impinge upon the adhesively coated side of the paper and thus, by manipulation of the arms 116, an adjustment of the pressure of the roller 109 may be attained.

It will be understood that while the electrostatic and electromagnetic means for coating counter to gravity are illustrated in Figures 8 and 9, the mechanical means hereinabove described may be conveniently employed in these locations without departing from the spirit of the invention. However, the reason the electromagnetic and electrostatic elements are particularly shown here is that the difficulty of counter coating successfully with the coarser grains is more likely to arise with these elements than with the vibrator or air blast heretofore described.

It will be understood that the forms of the invention disclosed herein employing electromagnetic fields are suitable for use with magnetically responsive materials but that other grit or abrasive material may be coated with a magnetically responsive film which would render the grit responsive to the action of the magnetic or electro-magnetic fields.

In the actual production of this invention, particularly where an electrostatic field is employed, some grit sizes require the employment of very high voltages and in employing such high voltages it will be appreciated by those skilled in the art that this involves the construction and installation of special electrical apparatus for producing and maintaining the high voltages, and at the same time necessitates the provision of adequate protection for workmen engaged in the production of sandpaper or the like abrasive article under these conditions.

The form of the invention shown in Figure 7 hereinabove described, is found to be of value in that lower voltages may be employed for producing deposition and orientation of the particles of grit, inasmuch as there is a constant mechanical force exerted on the particles tending to move them toward the sheet to be coated. It is to be noted that the screen disclosed in Figure 3 may be omitted and a controlled supply of the particles to the outlet afforded in any convenient manner. Furthermore the mounting of the hopper in Figure 3 may be adjusted so that the outlet is moved toward or away from the sheet as desired. In this instance, due to the force of gravity on the mass of abrasive particles contained in the hopper bearing on those adjacent the outlet, the particles are moved upwardly toward the sheet by the mechanical force thus exerted. Coupled with this, an electrostatic field of a relatively lower voltage or difference of potential may be employed.

Owing to the fact that the structure of Figure 3 involves the provision of means for obtaining a nicety of control and balance which might readily become out of control in use, I have provided the forms of the invention shown in Figures 11 and 12.

In the structure of these figures it is possible to control to a nicety the mechanical and electrical forces exerted to obtain the desired result, namely, orientation of the particle on the adhesively coated sheet with its major axis perpendicular to the sheet.

Referring now to Figure 11, it will be observed that a flight of paper follows the path similar to that shown in Figure 6, the paper being indicated at 86a, and being coated on one side from a tank 88a, and supplied to the coating apparatus with one flight 87a of the paper, having its adhesively coated side presented downwardly. Beneath the adhesively coated flight 87a, I provide a conveyor 96a on which grit particles are deposited from a controlled hopper 98a having a gate 81a. The conveyor 96a supplies the grit particles in a direction to the left as viewed in Figure 11 to a point below the adhesively coated flight 87a of the paper web.

Beneath the conveyor 96a adjacent to the point of deposit of grit on the sheet, I provide a beater 68a, similar to that shown in Figure 6. The beater and conveyor are mounted on suitable supporting means comprising the arm 64a, and toggle means 65a for adjusting the arm and the conveyor.

Also supported from the arm 64a I provide an electrode 76a, which has a complemental electrode 71a located above the horizontal flight 87a of the paper web, thus the beater acts to raise the grit particles from the conveyor 98a and may be regulated so as to exert a force insufficient for causing the particles to reach the adhesively coated sheet 87a, but when the electrical field is established between the electrodes this field combining its forces with the mechanical force exerted by the beater will serve to cause the particles to be propelled on to the adhesively coated surface and due to the polarisation effect of the electrostatic field to orient the particles with their major axes substantially perpendicular to the adhesively coated sheet.

It will be understood that by proper control of the electrostatic field and the mechanical forces imparted to the particles by the beater 68a that quite as desirable effects can be obtained in the ultimate abrasive article as are obtained in the other forms of the invention already described. Furthermore, this form of the invention permits of the employment of a much lower difference of potential or voltage between electrodes for obtaining the desired result.

Referring now to Figure 12, there is provided a web of paper trained over rolls 8a and coated at 8a by rolls 9a and 8a, this web being so trained over additional rolls as to present an adhesively coated flight 18a with the adhesive presented downward.

Beneath the flight 18a I provide a supporting arm 21a having mounted thereon a conveyor 19a

receiving sand from a hopper 28s. The arm 22a may be adjusted by a toggle mechanism indicated at 24a and the conveyor 18a conducts grit from the hopper 28a to the point beneath the flight 18a of the adhesively coated web.

At this point I provide a plurality of nozzles 27a delivering an air blast upwardly through the conveyor 18a, said conveyor preferably being of a screen character permitting the air stream to pass through the conveyor and to tend to raise the grit particles into the space between the conveyor and the adhesively coated surface of the flight 18a.

Above the flight 18a I provide an electrode 29a and the air blast nozzles 27a may serve as another electrode supplemental to the electrode 29a.

Thus an electrostatic field may be established between the electrode 29a and the nozzles 27a, but of insufficient force to, operating alone, lift the grit particles and deliver them to the adhesive sheet, but coupled with the agitation of the particles caused by the air blast, the combined forces of the air blast and the electrostatic field serve to deposit, orient and distribute the particles in the desired position on the adhesively coated flight 18a.

If desired, a separate electrode 27b may be added instead of employing the nozzles 27a as electrodes.

Referring now more particularly to Figures 13 and 14, it will be observed that here, in place of the two electrodes forming the electrostatic field, as shown in Figures 11 and 12, I may substitute electro-magnets 71b and 72b, located above the flights 87b and 87c of paper to be coated.

It will be understood in this instance that the grit particles will either be of an inherently magnetically responsive character or provided with a treatment such as a coating of electromagnetically responsive material for permitting them to be acted on by the magnetic field and directed toward the adhesively coated underside of the flights 87b and 87c of the paper.

The beater is schematically indicated at 88b in Figure 13, and the air blasts are schematically indicated at 27b in Figure 14.

It will be understood that the remaining portions of these figures are substantially the same as that shown in Figures 11 and 12 and further reference thereto is, therefore, not deemed to be necessary.

I wish to point out that where the expressions "electromagnetic" and "electrostatic" are employed in the specification, I refer to the employment as well of a permanent magnet or some other form of static charge or magnetic charge which will perform the function.

Features herein not specifically claimed in the aforementioned Carlton applications are reserved for companion applications Serial No. 401,484, filed July 8, 1941, and Serial No. 452,822, filed July 23, 1942.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is:

1. In an apparatus of the character described, including means for adhesively attaching pulverulent material to a backing, the combination comprising means for supporting a backing, means for applying an adhesive thereto and means below said backing for feeding a pulverulent material, and magnetic means for orienting said material in respect of said backing.

2. In an apparatus of the character described, means for supporting a backing, means for applying an adhesive thereto and means below said backing for feeding a pulverulent material, and electromagnetic means for applying said material to said backing.

3. In a coating apparatus, in combination, means for feeding an adhesively coated sheet in the direction of its surface, means for mechanically moving particles of abrasive material and said sheet towards each other, and magnetic means for establishing an electrical field for acting upon the particles for orienting them in respect of the sheet.

4. In an apparatus for manufacturing abrasives, in combination, means for mechanically moving particles of abrasive material and an adhesively coated sheet downwardly faced toward each other, and means for subjecting the said particles to the action of a magnetic field.

5. In an abrasive coating apparatus, in combination, means for feeding an adhesively coated sheet with the adhesive surface presented downwardly, means for supplying, adjacent to said surface, abrasive particles, said means including bringing said surface and abrasive toward each other, and means for subjecting said particles to the action of a magnetic field for orientation thereof in respect of said surface.

6. In a coating apparatus for coating with abrasive particles in combination, means for feeding an adhesive coated sheet, means for mechanically bringing said particles of abrasive material and said sheet towards each other, and means for establishing a magnetic field for acting upon the particles for orienting them in respect of the sheet.

7. Apparatus for the manufacture of web coated with oriented granular material comprising means for producing a magnetic field, means for supporting an adhesive coated web in said field, means located on the adhesive coated side of said web for introducing magnetically susceptible particles into said field, said apparatus being adapted to magnetically project said particles onto the adhesive coated web and orient them with respect thereto.

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[fol. 614]

Sept. 7, 1943. N. E. OGLESBY 2,328,577

PROCESS AND APPARATUS FOR GRADING AND FOR COATING WITH COMMINUTED MATERIAL

Filed Jan. 12, 1940 2 Sheets-Sheet 1

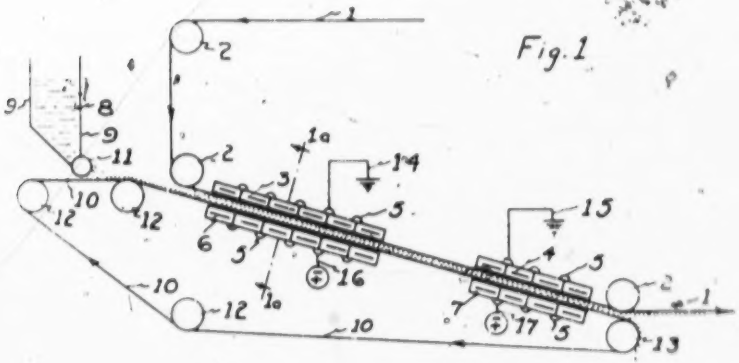

Fig. 1

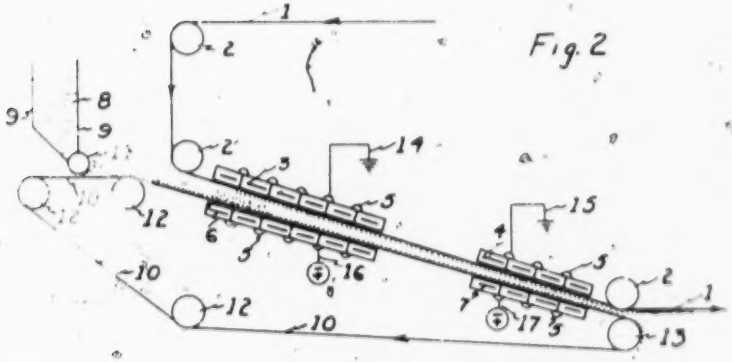

Fig. 2

Fig. 1a

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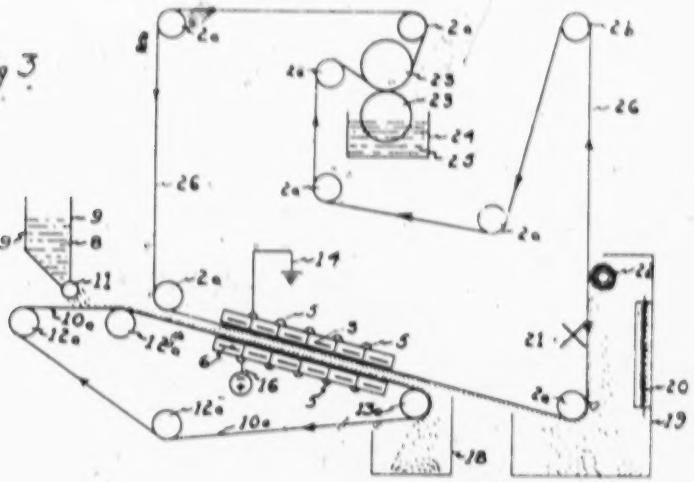
PROCESS AND APPARATUS FOR GRADING AND FOR COATING WITH COMMINUTED MATERIAL

Filed Jan. 12, 1940 2 Sheets-Sheet 2

Fig 3



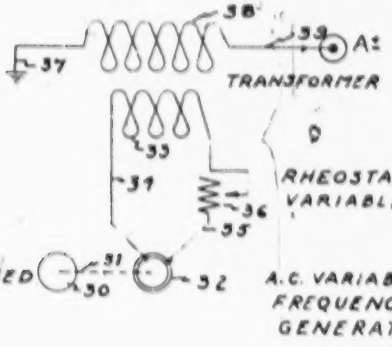


Fig 4

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Patented Sept. 7, 1943

2,328,577

UNITED STATES PATENT OFFICE

2,328,577

PROCESS AND APPARATUS FOR GRADING AND FOR COATING WITH COMMINUTED MATERIAL

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Application January 12, 1940, Serial No. 313,669

12 Claims. (Cl. 117—17)

This invention relates to the separation or grading of comminuted material such as abrasive grains, flocks, and the like, and is particularly concerned with improved electrostatic separation or electrostatic grading methods. More specifically this invention also relates to coating all or part of the separated or graded comminuted material onto an adhesively coated foundation material.

It is an object of this invention to coat the finer and less effective abrading particles, from a mixture of abrasive particles, on the bottom of a coated abrasive coating and to coat the coarser abrasive particles on the top of the coating. It is a further object of the invention to use an abrasive grain which has been less accurately graded than has heretofore been considered necessary and to coat such an abrasive in such a way that the top or effective abrading grains will be more uniform in grade than the average grade or size of all the grains coated. Another object of the novel method of coating provided in this invention is to avoid coating relatively coarse particles with which the mixture of abrasive grains delivered to the coating machine may be contaminated, or to coat a finer grade of abrasive than the average grade of abrasive delivered to the coating means. A further object of this invention is the production of a relatively deep coating of abrasive grains in oriented relation, with a non-loading or open spaced oriented grain effect at the top of the coating. Still another object of this invention is the provision of suitable apparatus for carrying out the novel processes described. It is a further object of this invention to separate abrasive grains of variable size into two or more fractions, one of which is coarser than the other. In stating the foregoing objects of the invention, abrasive grains are given as a preferred illustration of the material worked upon by the novel process and apparatus. It is to be understood that other comminuted material, such as flocks, may be coated or handled in an analogous way, and that abrasive grains are representative materials that may be processed in accordance with this invention.

The method and apparatus by which my invention is carried out will be explained by reference to the accompanying drawings, in which:

Figure 1 is a side elevation of one form of apparatus which may be used for carrying out my invention;

Figure 1a is a section on the line 1a—1a of Figure 1.

Figure 2 is a side elevation showing a modification of the apparatus used in Figure 1;

Figure 3 is a side elevation of a form of apparatus for carrying out another modification of the invention;

Figure 4 shows a wiring diagram for obtaining the variable frequency alternating current of high potential used in carrying out my invention.

Similar reference characters refer to similar parts throughout the several drawings.

Referring to Figures 1 and 2:

Numeral 1 is an adhesively coated web such as paper or cloth, or combinations of paper and cloth. Numerals 2 represent suitable idler rolls over which the web 1 is continuously drawn through the electrostatic field, by means not shown. Numeral 3 represents an electrode which may be a solid electrode or a bank of electrodes as illustrated in Figures 1 and 2. In the same way numerals 4, 5 and 7 represent electrodes which may be solid or a bank of individual electrodes, as illustrated in the figures. The electrodes may be made of suitable metal or other conducting material and they may be insulated or not insulated, but I generally prefer to use insulated electrodes, phenol formaldehyde resin or paper impregnated with such resins forming a suitable insulating covering for the electrodes or banks of electrodes. Numeral 5 represents connections between the individual electrodes forming a bank of electrodes, as for instance, electrode bank 3 may contain six electrodes connected together as indicated by numeral 5. Various sized electrodes may be used but an electrode having a dimension of about 6 inches in the direction of travel of the web and surrounded by ¼ inch of insulation has been found generally satisfactory for my purpose. With each individual electrode having a conducting dimension of 6 inches in the direction of travel of the web and ¼ inch of insulation surrounding the conductor, the electrode bank 3 containing six such electrodes would have a total dimension of 3¼ feet in the direction of travel of web 1. In the same way, electrode bank 4 would have a total dimension in the direction of travel of the web 1 of 2 feet 2 inches, but I may use greater or shorter dimensions of electrodes in the direction of travel of the web, according to the result desired. Numeral 6 denotes comminuted material, as for instance, abrasive grains held in a hopper 9. The grain 6 is fed from the hopper by feed roll 11 driven by means, not shown, and deposited on endless belt 10. Numerals 12 represent idler rolls around which belt 10 is directed and driven continuously by roll 13 which is driven

by conventional means, not shown. Numeral 14 is a conducting connection connecting electrode 3 or electrode bank 3 to ground. Numeral 15 is a conducting connection connecting electrode or electrode bank 4 to ground. Numeral 16 is a conducting connection connecting electrode 6 or electrode bank 6 to a source of high potential of variable frequency and alternating polarity. Numeral 17 is a conducting lead connecting electrode 7 or electrode bank 7 to a source of high potential of variable frequency and alternating polarity or to a source of unidirectional high potential (direct current). The order of connections of electrodes may sometimes be reversed in that conducting lead 14 may be connected with a source of high potential of variable frequency, and connecting lead 16 may be grounded. Likewise, conducting lead 15 may sometimes be connected to a source of high potential of suitable characteristics, and connecting lead 17 may be grounded. The abrasive grains 8 are delivered from hopper 9 by feed roll 11 onto the endless belt 10 which is moved continuously into the electrostatic field set up between electrodes 3 and 6. The high potential alternating current applied to electrode 6 where electrode 3 is grounded or to electrode 3 where electrode 6 is grounded is of a variable number of cycles, depending upon the grit sizes and variation in grit sizes being separated and coated. The number of cycles is adjusted so as to lift only the smaller grains to the adhesively coated web, the larger grains being lifted a shorter distance and dropping and/or being pulled back to the carrier belt upon the reversal of polarity. I have discovered that a superior separation of the smaller and larger grains can be accomplished by adjusting the frequency in accordance with the size of grains that it is desired to coat in the field between electrodes 3 and 6. I generally prefer, especially in the case of fine grits, to use a voltage sufficient to lift all of the grains from the belt 10, as I believe effective separation is brought about because the smaller grains travel faster when lifted from the belt and, with the correct electrode spacing, reach the adhesively coated backing at a point of time at which the larger grains have traveled a shorter distance. By a proper selection of frequency the polarity of the field is reversed before the larger grains reach the adhesively coated backing. As stated above, the small grains are lifted to the adhesively coated web while the larger grains are lifted a shorter distance. The frequency of alterations of polarity of the field is so adjusted and controlled that the average displacement of the finer particles per electrical impulse is substantially greater than the average displacement of the larger particles. Of course, the average displacement of the larger particles is less than the free space distance between the electrodes 3 and 6, and, in fact, less than the distance between the felt 10 and the adhesively coated surface of web 1. Irrespective of the mechanism it has been found possible to coat the finer grains in oriented relationship and have the larger grains pass out of the field between electrodes 3 and 6 on the carrier belt 10. As the belt moves forward it carries the larger grains which are not coated in the field between electrodes 3 and 6 into the field between electrodes 4 and 7. Electrode 7 is connected to a source of high potential of variable frequency when electrode 4 is grounded or electrode 4 is connected to a source of high potential of variable frequency when electrode 7 is grounded. I impress upon electrode 7 or electrode 4, as the case may be, a lower frequency alternating current whereby, for a given electrode spacing, a longer time of travel is permitted so that larger particles reach the adhesively coated backing than was the case between electrodes 3 and 6. By suitably controlling the frequency of the field between electrodes 4 and 7 I may control the size of particles coated in this field. Often, however, it is desired to coat all or a large portion of the particles remaining on the belt in the field between electrodes 4 and 7. In this case I may use direct current instead of an alternating current in establishing this field or I may use an alternating current of relatively low frequency, as for instance, a frequency of 10 to 30 cycles or lower. A separation of the grain into larger and finer fractions may take place in the field between electrodes 7 and 6 or in both fields. In either case the average size of the grain coated depends upon the electrode spacing, the voltage, and the number of cycles.

The separation desired is not attained by the use of a simple pulsating direct current with a variable frequency of pulsation, since charges are not lost by the particles and the electrodes with sufficient rapidity, and a particle once charged and set in motion between the electrodes continues to travel even though the connection to the source of direct high potential is interrupted. Where alternating current is used the field is reversed, and a particle with a given charge and in motion is reversed in direction of travel with the reverse in polarity and I believe this to be the reason why better separations are attained with alternating current. Instead of using simple alternating current, a commutator may be used to reverse the polarity of the electrodes where they are energized with direct current but I prefer to use alternating current as it is simpler and very effective for my purpose.

The voltage impressed upon an electrode, the spacing between the electrodes and different banks of electrodes, the length of the electrodes along the direction of travel of the adhesively coated web, and the frequency of the alternating current used, are varied according to the grit size and the result that it is desired to attain.

In the prior art, abrasive grains have been coated to a sheet by passing the adhesively coated backing through an electrostatic field adjacent an upper electrode with the adhesive side facing downwardly and passing abrasive grains into the electrostatic field, often by means of a belt moved adjacent to the lower electrode in its passage through the field. In this and in other methods of the prior art, spacings, voltages and frequency of the current, where alternating current has been used to energize an electrode, have been such as are conducive to coating the adhesively coated web quickly and completely with a grade of abrasive grains which at least approaches the grade of the abrasive grain delivered to the electrostatic field. In actual practice, however, with direct current, either uninterrupted or interrupted, or with alternating current of relatively low frequency and an air gap which is often relatively small, the result has been that all of the abrasive grains are propelled to the adhesively coated backing sheet. Some grains are retained by the adhesives, others immediately return to the carrier belt and are again propelled to the adhesively coated backing and this process is continued as the web travels forward through the field between the electrodes. The weight of abrasive coated gradually increases due to repeated bom-

bardments as the web passes through the field. If the energizing current furnished to the electrode is cut off suddenly, the pieces of backing within and corresponding to the length of the field at the time the current is broken may be sampled and analyzed at any desired point within the coating field. It will be found that the grade of abrasive being coated as the web enters the field is usually at least substantially as coarse as the abrasive delivered to the field, and that the overall grade of abrasive decreases progressively as the weight of abrasive coated is built up from the beginning of the electrodes to the end of the electrodes in the direction of travel of the web. By computation of grades, it will be found that the last abrasive coated as the web leaves the field is very fine as compared with the grade of abrasive delivered to the field. I attribute this to the fact that as the abrasive weight coated builds up in the field the spaces between the grains become small and it is, therefore, easier to embed the fines between the grains already coated than the average size or coarser size of grains still remaining in the abrasive mixture. At any rate, in the prior art the result has been the embedding of fine grains between coarser grains toward the end of the coating operation in the electrostatic field. It should be understood that the presence of such very fine and ineffective grains between the more effective abrading grains is what we term "a fine top effect" in this application, a condition which is conducive to loading of the product by the work removed in abrading and which interferes with the efficiency of the product. It should be appreciated that a product built up according to the present invention avoids the difficulties of the prior art in that a substantial proportion of the fines content is coated onto the adhesively-coated backing at the beginning of the coating operation thereby removing these fines from the abrasive mixture—that they will not be embedded between the coarser and more effective grains in the later stage of the coating operation wherein I provide conditions conducive to coating coarser grains.

As an example of the use of the invention as illustrated in Figure 1, I may consider a coating carried out with grit No. 280 silicon carbide abrasive. The actual grading of the abrasive of this fine number is commonly determined by sedimentation. From the sedimentation results, an accumulation curve is plotted which shows the diameter of the grain in terms of microns versus the percentage of grain. It should be appreciated that grains of this fine size and finer sizes, and sometimes somewhat coarser sizes, are graded by air or water classification methods. The grading set forth, as determined by microns, is a statistical value, and the cleanliness of the grade can be determined by plotting a distribution curve. A clean grade is one having a high percentage at or near the nominal size and relatively free from substantially coarser or finer grades of grain. Where I speak of a flour grade being finer than another flour grade I mean that the average grain size of the finer grade is finer. Where I speak of a cleanly, well, evenly or uniformly graded material I mean that the material has a relatively steep distribution curve, shows a relatively high percentage of grain at or near the nominal size and is relatively free from grains much finer or much coarser than the nominal size. At the 50 percent point on the accumulation curve, the standard diameter for grit No. 280 silicon carbide is 44 microns. The abrasive delivered from the hopper 8 of Figure 1 in this coating had a diameter at the 50 percent point on the accumulation curve of 47 microns. This abrasive when coated by the regular method of upward propulsion, (i. e., electrostatic movement of particles counter-to-gravity), which does not involve the invention disclosed in this application to produce a coated abrasive article with an abrasive weight of 4.04 pounds per sandpaper ream, showed an overall grading at the 50 percent point on the accumulation curve of 44.5 microns. In the coating by the regular conventional method, the abrasive that first adhered to the sheet was coarser than that which later adhered to the sheet in the travel of the adhesively coated web between the electrodes. The abrasive which was coated onto the adhesively coated backing just before the coated web emerged from the electrodes was very fine, as was determined by stopping the machine and analyzing the grade of the abrasive at several points along the line of travel of the web through the field. For both the conventional coating and the novel method herein described, 40 pound rope paper was used as the web to be coated and the adhesive coated on the backing by conventional means to hold the grain consisted of a solution of an oil-modified alkyd resin composition in high flash naphtha, the solution containing about 65 percent of nonvolatile resinous material. In the control experiment the coating electrodes were energized with an alternating current of 25 cycles stepped up to 40,000 volts and the air gap between the belt carrying the abrasive and the upper electrodes was uniformly ½ inch.

In coating according to the present invention the apparatus shown in Figure 1 was used. The air gap between the upper bank of electrodes 3, which was grounded, and the belt 10 carrying the abrasive, was uniformly 1½ inches. The electrode bank 3 was energized by 60 cycle alternating current stepped up to 31,000 volts. It was desired to coat only a small portion, and the finer portion, of the abrasive grain of grit No. 280 on the belt 10 in the field set up between electrodes 3 and 6. The abrasive weight attained in the field between electrodes 3 and 6 was 1.23 pounds per sandpaper ream and the grading of the abrasive coated at the 50 percent point on the accumulation curve was 37.5 microns. The adhesively coated web was 36½ inches wide and was moved through the field, adhesive side facing downwardly, at a speed of 102 feet per minute. The feed roll 11 delivered to the carrier belt 10, in a continuous manner, 5.4 pounds of abrasive per minute. The belt 10 was moved through the field at a rate of 7½ feet per minute. The layer of abrasive on belt 10 was 38 inches wide. The coarser abrasive not coated in the field between electrodes 3 and 6 was allowed to dump from the belt at the point of roll 12 and was collected for re-use. In the coating operation described the coated abrasive formed was finer in grade and more uniform in grade than the abrasive fed to the belt 10. Also, the grains were coated in oriented relation.

In the form of apparatus shown in Figure 1, there is for a single setting, a constant air gap at all points between electrode bank 3 and the carrier belt 10. In practicing the invention with this form of apparatus, the same or a different spacing or air gap may be provided between electrodes 4 and 7. In the form of apparatus shown in Figure 2 there is, as shown in the figure, a gradual decrease in the air gap from the begin-

ning of electrodes 3 and 6 to the end of electrodes 4 and 7. For certain purposes there is an advantage in the form of apparatus shown in Figure 2, in that a wider gap, conducive to good separation, may be used for the first bank of electrodes and a narrower gap, conducive to complete coating of all the grain, may be provided in a second bank of electrodes, 4 and 7. A variety of arrangements will occur to those skilled in the art. The distance between the electrode banks 3 and 6 and electrode banks 4 and 7 is not critical so long as the two banks of electrodes are not so close to each other than there is an interference between the two fields. In general I find a spacing of about 7½ inches very satisfactory.

As a further illustration of the use of my invention I may describe the coating of grade No. 240-A waterproof sandpaper. In this instance the form of apparatus shown in Figure 2 was used. The air gap between electrode bank 3 and the abrasive-carrying belt 10 at the point where the belt first enters the field was 1¼ inches. The spacing between the two pairs of electrodes was 7½ inches. The electrode banks 3 and 6 were made up of six electrodes with a dimension in the direction of travel of the adhesively coated web of 6½ inches each (including insulation). The second bank of electrodes was made up of only one electrode with a dimension of 6½ inches (including insulation) in the direction of travel of the adhesively coated web. The air gap at the end of the electrodes 4 and 7 where the carrier belt 10 emerges from the field was ⅝ inch. As an adhesive, a 71 percent solution of oil-modified alkyd resin composition dissolved in high flash naphtha was coated onto the web by conventional means, not shown. The web was 40 pound rope paper previously treated by conventional means to fill the pores and waterproof the web. The web was 36½ inches wide. A layer of No. 240 silicon carbide abrasive, 38 inches wide, was fed onto abrasive-carrier belt 10 at the rate of 6.95 pounds per minute from hopper 9 by feed roll 11, as shown in Figure 2. In the coating operation the web 1 was moved through the field with the adhesively coated side facing downwardly, by conventional means, not shown, at a rate of 102 feet per minute. The abrasive-carrier belt 10 moved at a speed of 7½ feet per minute. The abrasive grain fed had a grading of 59.5 microns at the 50 percent point on the accumulation curve. Electrode bank 6 was energized by an alternating current of 60 cycles at 24,000 volts. Electrode 7 was energized by an alternating current of 15 cycles at 40,000 volts. Between the electrodes 3 and 6 an abrasive weight of 2.35 pounds per sandpaper ream was coated. At the 50 percent point on the accumulation curve the abrasive so coated graded 46 microns. Between electrodes 4 and 7, 3.25 pounds per sandpaper ream of abrasive was coated, giving a total weight of coated abrasive of 5.6 pounds. The grading for the total abrasive weight applied was, at the 50 percent point on the accumulation curve, 56.5 microns. The abrasive applied in the first bank of electrodes was, therefore, 10.5 microns finer than the overall grading of the abrasive applied to the sheet. From this it is evident that that part of the abrasive, coated between electrodes 4 and 7, was much coarser than that coated between electrodes 3 and 6. In coating with both electrode banks a total of 76 percent of the abrasive delivered to the carrier belt 10 was coated and 24 percent of the abrasive fed was dropped off the belt and recovered for re-use as the belt passed over roll 13. The 24 percent of grain recovered at roll 13 was suitable for use in making a coarser grade of coated abrasive. The abrasively coated web 1 was passed by conventional means, not shown, from the abrasive-applying means of Figure 2, to a conventional drying chamber, in which the coated goods were heated to cure the resinous binder. An excellent coated abrasive was produced in which the top of the abrasive coating was remarkably free from fines which in the prior art caused poorer abrading action and a tendency of the abrading device to load with material being removed from the object being abraded. The abrasive grains in the coating were well oriented.

As a still further illustration of the use of my invention I may describe the coating of grade No. 220-A waterproof sandpaper. Grade No. 220 is a grade controlled by screens and not by sedimentation. In this instance the form of apparatus shown in Figure 2 was used. The air gap between the electrode bank 3 and the abrasive-carrying belt 10 at the point where the belt first enters the field between electrodes 3 and 6 was 1¼ inches. The spacing between the two banks of electrodes was 7½ inches. The electrode banks 3 and 6 were made up of six electrodes each with a dimension in the direction of travel of the adhesively coated web of 6½ inches (including insulation). The second bank of electrodes, 4 and 7, was made up of two electrodes with a dimension of 6½ inches each (including insulation) in the direction of travel of the adhesively coated web. The air gap at the end of the electrodes 4 and 7 where the carrier belt emerges from the field was ⅝ inch. As an adhesive a 74 percent solution of oil-modified alkyd resin composition, dissolved in high flash naphtha was coated onto the web by conventional means, not shown. The web was 40 pound rope paper previously treated by conventional means to fill the pores and waterproof the web. The web was 36½ inches wide. A layer of No. 220 silicon carbide abrasive, 38 inches wide, was fed onto the abrasive carrier belt 10 at the rate of 7.45 pounds per minute from hopper 9 by feed roll 11, as shown in Figure 2. Adhesively coated web 1 was moved through the field by conventional means, not shown, at 102 feet per minute, while the abrasive-carrying belt 10 moved at a speed of 7.5 feet per minute.

The abrasive grain fed had a fines content as determined by the use of a Number 325 standard silk screen of 46.6 percent. Electrode bank 6 was energized by an alternating current of 60 cycles at 24,500 volts. Electrode bank 7 was energized by an alternating current of 15 cycles at 30,000 volts. Between the electrodes 3 and 6 a sand weight of 3.4 pounds per sandpaper ream was coated. Grain so coated showed a fines content of 56.9 percent as determined by a number 325 standard silk screen. Between electrodes 4 and 7, 3.1 pounds of abrasive were coated to give a total abrasive weight on the coated sheet of 6.5 pounds per sandpaper ream. The fines content of the total abrasive weight so applied was 50.7 percent as determined by the number 325 standard silk screen. The abrasive applied in the first bank of electrodes, therefore, contained 8.1 percent more fines than the average of the abrasive coated in both abrasive-applying operations. The abrasive coated in the second operation between electrodes 4 and 7 was, therefore, decidedly coarser and freer from fines, as could be readily detected in the appearance of the coat-

ed product as compared with a product coated by conventional counter-to-gravity electrostatic means with the same abrasive to the same abrasive weight. In coating with both pairs of electrode banks, a total of 82.5 percent of the abrasive delivered to the carrier belt 10 was coated and 17.5 percent of the abrasive fed was dropped off the belt and recovered for re-use as the belt passed over roll 15. The 17.5 percent of grain recovered was suitable for use in making a coarser grade of coated abrasive.

In a manner analogous to which No. 240-A waterproof sandpaper was made with grade No. 240 silicon carbide, I will describe a coating in which No. 320-A waterproof sandpaper was made. In this case conditions were similar to the manufacture of No. 240-A waterproof sandpaper, except that a current of 120 cycles at 29,400 volts was used to energize electrode bank 6 and a current of 25 cycles at 36,000 volts was used to energize electrode bank 7. The air gap between electrode bank 5, in this case made up of three electrodes with a dimention 6½ inches each, in the direction of travel of web 1, and carrier belt 10 at the point where carrier belt 10 enters the field was 1⅛ inches. The air gap between the carrier belt 10 and the electrode bank 4 in this case made up of two electrodes having a dimension of 6½ inches each in the direction of travel of web 1 at the point where carrier belt 10 emerges from the field, was ⅛ inch. As in previous instances, the abrasive coated on the bottom between electrodes 5 and 6 was much finer than the abrasive coated between electrodes 4 and 7 and the top coating of abrasive grains was very free from fines and therefore more effective as an abrading instrument. The coated grains were well oriented.

No specific rules can be given for electrode spacings, frequency, and voltage, for every condition that will be encountered. In general, however, electrode spacings in excess of 2 or 3 inches are not preferred since excessive voltages would be required and since, for some reason unknown to me, electrostatic action is more practical at smaller electrode spacings. In general with the finer grits and a well covered carrier belt a voltage should be used which is high enough to readily lift the abrasive grains from the carrier belt and which is not high enough to cause arcing between the electrodes. The frequency of the alternating current used to make the separation in the coating operation in the step where the finer abrasive is removed from the abrasive mixture fed to the field varies with the grit size and the electrode spacing. Generally speaking, the wider the air gap the lower the frequency that can be used to make the separation, and the finer the grain the higher the frequency desired to make a satisfactory separation. I select a practical air gap spacing and voltage and then use that frequency most effective for obtaining the desired results of selectively removing a finer grade of abrasive from the coarser and variable grade delivered to the field. I then use conventional voltages, electrode spacings, or air gaps and a direct current, either uninterrupted or interrupted, or a suitable frequency of alternating current for coating additional abrasive as required for the results desired in the second abrasive-applying step, where such second step is employed, as for instance, between electrodes 4 and 7 of Figure 1 and 2.

Figure 3 illustrates another form of my invention and differs from the forms shown in Figures 1 and 2 in that in this form of the apparatus the finer abrasive removed from the abrasive mixture fed to the device shown in Figure 3 is not permanently coated onto a reinforcing backing but is, on the contrary, removed after separation and collected for subsequent use as desired. In Figure 3, numerals 2a represent idler rolls over which an endless belt 26 is trained, belt 26 being made of paper, cloth, or other suitable material. Idler roll 2b is driven by conventional means, not shown, at any desired speed. Numerals 3, 5, 6, 8, 9, 11, 14 and 16 denote parts which may be identical with parts denoted by similar numerals in Figures 1 and 2 and already described. Numeral 16a represents an endless belt which may be made of cloth or other suitable material. The belt 16a is trained about idler rolls 12a and a power driven roll 13a which is driven by conventional means, not shown, at any desired speed. Numeral 18 denotes a suitable receptacle in which the abrasive or other comminuted material dumped from belt 16a at roll 13a may be recovered. Numeral 19 represents a receptable or chamber in which the abrasive or other comminuted material removed from belt 26 may be recovered. Numeral 20 represents a heater which may be used to evaporate liquid applied to belt 26. Numeral 21 represents a rattler or beater which is driven by conventional means, not shown, and aids in the removal of abrasive or other comminuted material from belt 26 so that it may be recovered in receptacle 19. Numeral 22 designates a rotating brush driven by conventional means, not shown, to remove the abrasive or other comminuted material, if required, and as desired, from endless belt 26, so that it may be recovered in receptacle 19. Numerals 23 denote conventional coating rolls driven by conventional means, not shown, which may be used to apply a liquid coating material to the endless belt 26. Numeral 24 represents a coating trough in which the liquid to be coated to roll 26 is placed so as to contact lower coating roll 23. Numeral 25 denotes the liquid which is placed in coating trough 24. In some instances, especially in the case of very fine grits, water will be found effective. In other cases, a small quantity of a surface tension-lowering agent, such as sulphonated vegetable oil, sulphonated higher alcohol or other suitable surface tension-lowering agent is added to the water and used. In still other cases a small quantity of soluble and usually mild adhesive, such as starch in solution, is used. In lieu of water, other volatile liquids or solvents may be used. The form of the invention shown in Figure 3 is particularly useful as an abrasive-separating mechanism. Furthermore, it is particularly useful in separating the so-called flour grades or grades within the range of No. 240 and finer. The abrasive which it is desired to separate, which may be a mixture of different sizes of silicon carbide, aluminum oxide, or other abrasive, preferably containing particles of the size normally found in grades 240 and/or finer, is delivered from hopper 9 by speed roll 11 onto carrier belt 16a which is driven by roll 13a at any desired speed, as for instance, 7 to 10 feet per minute, through the electrostatic field set up between electrodes 3 and 5, the rate of feed being governed by the results that it is desired to attain, as previously described in instances where it was desired to permanently coat the finer fracture of grain removed from the abrasive mixture. The endless belt 26 is coated with water or other suitable

material, usually with little or mild adhesive action in the liquid state, by coating roll 23 dipping in the coating liquid 25 in trough 24, as the endless belt 26 is moved in the direction of the arrow around idler rolls 2a by power driven roll 2b at a suitable speed, as for instance, 85 to 125 feet, although other speeds will often be found satisfactory. Electrode bank 3 or electrode bank 8 is grounded and the opposing electrode is energized by an alternating current, the frequency of which is controlled according to the results desired. I have found a frequency of 60 cycles quite effective for grit sizes of the order of No. 220, No. 240 and No. 280, provided the correct voltage is used and the correct air gap is employed. As a rule a suitable air gap for grades of this size will be about 1 to 1½ inches. By this I mean the air gap between belt 16a in Figure 3 and electrode bank 3. The air gap may be the same at the point where the belt 16a enters the field as where the belt leaves the field or the gap may be varied, that is, electrode banks 3 and 8 may be parallel or at a slight angle to each other in accordance with the results desired. Likewise, I may vary the length of the electrodes in the direction of travel of the endless web 26 and the endless belt 16a. Generally speaking, the longer the electrodes the greater the quantity of abrasive that will be removed from the mixture of abrasive or other comminuted material delivered to belt 16a. In operating with grades of this size range, I prefer to use a voltage that will lift all or most of the grains from the abrasive-carrying belt in the field between electrodes 3 and 8.

Where it is desired to separate grain sizes containing a considerable proportion of grains of still smaller size, that is, sizes smaller than the range 220, 240 and 280, I prefer to use still higher frequencies both for those forms of the invention in which the finer grains separated are permanently coated as in Figures 1 and 2 and in those cases where the finer grain is removed from the field and collected for a subsequent use as is illustrated in Figure 3. For instance, for separating the finer grains in a mixture of grains of the order of magnitude of sizes 320, 360, 400 and still finer, I may use frequencies between 60 and 180 cycles, as for instance, 120 cycles, as has already been used in illustrating the coating of grade 320 by means of the form of apparatus shown in Figure 2. Generally speaking, the conditions depend upon the nature and size of the particles in the mixture being separated, and for a given material substantially the same conditions will be found to operate where the finer grain is permanently coated as in Figures 1 and 2, and where the grain is only temporarily coated or otherwise removed from the field and collected for subsequent use as illustrated in Figure 3.

In the coarser grades, separation into different sizes is usually readily accomplished by means of screens but in some instances the present invention is useful in handling coarser comminuted material, such as the coarser grades of abrasive. Where a coarser abrasive mixture is separated by means of the present invention, a lower frequency may be used on the separating electrodes as for instance, electrodes 3 and 8 in Figures 1, 2 and 3. It should be appreciated that the controlling factor in selecting the correct frequency is that I select a frequency which permits the lifting of the finer portion of the mixture to the adhesively coated backing counter-to-gravity or in a direction with a component counter-to-gravity, an angle too vertical often being conducive to ease of operation of the equipment, and a frequency which also insures a reversal of polarity before the larger grains reach the adhesively coated backing, or other means of removing the finer material from the field.

In general the preferred operation of my process with fine grits presupposes that a definite layer of fine grits will be fed into the field on a carrier belt, as for instance, belt 16, or belt 16a, and that substantially all of the grains will be lifted from the belt during the separating operation. Where relatively coarse material is being handled, it sometimes may be preferred to coat the belt sparsely with grain and lift only the finer grains from the belt. This can be accomplished by correct adjustment of frequency, air gap and voltage. Considering solely the voltage, it should be understood that the voltage required is not always proportional to the grit sizes. For instance, there is a certain grit size, for example, of silicon carbide, that requires a higher voltage than either a smaller or larger particle to insure lifting of the particle. Considering the coarse grits, for example, of silicon carbide, that is, grits coarser than about 180, a higher voltage is required to lift the larger grains than the smaller grains in this same range. However, it frequently happens, and in fact, it is generally true, that a higher voltage is required to lift grit 280, for example, silicon carbide, than is required to lift grit 180 or 120. In other words, there is a minimum voltage requirement in size in the neighborhood of grit 180 and the voltage required to lift the particles rises on the coarse side of this point as the grit size increases and rises on the finer side of this point as the grit size decreases. This condition, however, does not nullify the basis of this invention which succeeds in separating fine abrasives even though a higher voltage may be required to lift the smaller particles, since in this grit range all particles are set in motion but the finer particles once in motion travel faster after leaving the abrasive carrier belt, for example, and the coarser particles are prevented from reaching the adhesively coated web or other collecting means by a reversal in polarity at the selected frequency.

Referring to Figure 4 which illustrates diagrammatically a set-up for obtaining any desired frequency of pulsation of alternating current and any desired potential from an electrode used in my coating process, 30 is a variable speed motor connected through suitable connecting means 31 to an alternating current variable frequency generator 32. Suitable motors, connections and generators are well known in the art. The alternating current generated in generator 32 is fed through conductors 34 and 35 to the primary winding 33 of a transformer. In conductor 35 between the motor generator and the primary winding 33 of the transformer is located a rheostat 36 for varying the voltage. The transformer may be of any desired type, but for purposes of illustration, I use a core type transformer. At 37 is shown a ground for the secondary winding 38 of the transformer, the secondary winding 38 of the transformer being connected to a suitable conductor 39 which leads to a suitable terminal A± which may be one of the electrodes indicated as connected to a high tension bus in Figures 1, 2 and 3 or may be a terminal which is in turn connected to one of the aforesaid elec-

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trodes. By such adjustments as are known in the art, the variable speed motor 30, the generator 32, the transformer windings 33 and 38 and the rheostat 36 may be controlled to obtain any desired frequency and potential at the terminal A±.

Electricity of characteristics suitable for carrying out my invention is readily supplied by apparatus of the type illustrated in Figure 4. This type of apparatus supplies electricity of characteristics well adapted for use in energizing electrode 6 of Figure 1, electrode 6 of Figure 2 and electrode 6 of Figure 3. The same type of apparatus may be used to supply alternating current, usually of lower frequency, to electrode 7 of Figure 1 or electrode 7 of Figure 2, where alternating current is used to energize electrode 7 of Figure 1 or of Figure 2. It is to be understood that the electrostatic separations carried out as illustrated in Figure 1 between electrodes 3 and 6, in Figure 2 between electrodes 3 and 6 and in Figure 3 between electrodes 3 and 6 are analogous. The fundamental difference is that where the apparatus is used for permanently coating to a reinforcing backing the finer portion of comminuted material, separated from the comminuted material of variable size, a relatively strong adhesive is applied to the reinforcing backing 1 of Figures 1 and 2, whereas, when it is desired to recover for subsequent use as such, the finer portion of comminuted material separated from the comminuted material of variable size, as between electrodes 3 and 6, in Figure 3, a liquid such as water or a mild adhesive is used to temporarily anchor the finer portion of comminuted material to the endless belt or carrier 26 so that the finer portion of material may be collected as illustrated in Figure 3 in receptacle 19 for further use as such. Recovery of the finer portion of material removed from the field by carrier 26 is facilitated by the heater 28 of Figure 3 which evaporates some or all of the liquid used to wet and adhere the grains temporarily to the carrier 26 or evaporates the volatile portion of the mild adhesive coated to carrier 26, so that the temporarily adhered grains may be more readily removed from the web by beater or rattler 21, and/or revolving brush 22.

It will thus be seen that there has been provided by this invention, methods and apparatus suitable for coating a controlled grade of comminuted matter such as abrasive grains to an adhesively coated backing, for separating comminuted material such as abrasive grain into two or more portions, one of which is of finer grade than the other portion, and for combining the steps of separating or grading comminuted material, such as abrasives, with the coating of the same to an adhesively coated backing, in a single operation. There has thus been provided by this invention, methods and apparatus in which the various objects hereinbefore set forth, together with many thorough practical advantages, are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention, and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A process of separating finer sized particles from comminuted material having particles of different sizes therein, comprising establishing an electrostatic field of alternating polarity, passing said comminuted material through said field, adjusting the frequency of alternations of the polarity of said field to separate from the comminuted material in the field only the finer sized particles of comminuted material, removing the finer sized particles so separated from said field, and collecting separately from the finer sized particles so removed, the coarser particles of comminuted material.

2. A process of separating finer sized particles and coarser sized particles from comminuted material having particles of different sizes therein, comprising establishing an electrostatic field of alternating polarity, simultaneously passing through said field separate means for removing therefrom the finer sized particles and the coarser sized particles, adjusting the frequency of alternations of the polarity of said field to separate from the comminuted material introduced into the field and to deposit upon the first-mentioned particle removing means only the finer sized particles, thereby removing the finer sized particles from the field, and separately removing on the second-mentioned particle removing means the coarser portion of said comminuted material.

3. In a process of coating a reinforcing backing with an abrasive material, the steps comprising passing an adhesively coated web through an electrostatic field of alternating polarity of controlled frequency adjacent an upper electrode of said field and with the adhesively coated side facing downwardly, passing abrasive grains of variable size through said electrostatic field adjacent the lower electrode, adjusting the frequency of alternation of the polarity of said field so that a finer portion only of said abrasive material is propelled to and embedded in said adhesive in oriented relation whereby the abrasive coating applied to said adhesively coated web is of a substantially finer grade than the abrasive grain delivered to said field and whereby a coarser abrasive grain with less variation in size is prepared for other abrasive use.

4. A process of coating a reinforcing backing with an abrasive material comprising passing an adhesively coated web through an electrostatic field of alternating polarity of controlled frequency adjacent an upper electrode of said field and with the adhesively coated side facing downwardly, passing abrasive grains of variable size through said electrostatic field adjacent a lower electrode, adjusting the frequency of alternation of the polarity of said field so that a partial coating of a finer portion only of said abrasive material is propelled to and embedded in said adhesive in oriented relation, passing said web so coated through a second electrostatic field adjacent an upper electrode of said second field, passing the abrasive grains not coated in the first electrostatic field into the second electrostatic field adjacent the lower electrode, and creating electrostatic forces in said second electrostatic field to cause a coarser portion of abrasive to be propelled to and embedded in said adhesive whereby the final composite abrasive coating applied to said adhesively coated web is relatively free from fine grains that have been embedded between the exposed portions of the coarser grains, and drying said coated web to set the adhesive and fix the abrasive grains to the backing.

5. A process of coating a reinforcing backing with abrasive material comprising passing an ad-

heavily coated web through an electrostatic field with the adhesively coated side facing abrasive supplied to said field, passing abrasive grains containing a substantial proportion of grains finer than the coarser portion of said grains through said electrostatic field and electrically propelling a partial coating of only a finer portion of said abrasive onto said adhesively coated backing in said field, passing said adhesively coated backing so partially coated with abrasive grains, while the adhesive is still in a condition to receive additional grains, through a second electrostatic field, supplying to said second electrostatic field coarser abrasive grains relatively free from grains of the size of grains coated in the first electrostatic field, and electrically applying an additional portion of a coarser size of abrasive to said previously partially coated backing, in said second electrostatic field, and setting the adhesive on the web so coated to hold the abrasive grains in place.

6. A combined process of grading abrasives and coating abrasives onto a reinforcing backing comprising passing an adhesively coated web through an electrostatic field with the adhesively coated side facing downwardly and adjacent an upper electrode, passing abrasive grains of suitable but variable size through said field; adjusting the electrode spacing, the voltage and the frequency of the alternating current used to energize an electrode of said field in accordance with the grade and quantity of abrasive that it is desired to coat on the backing in said electrostatic field and thereby propelling a controlled coating of abrasive grains into said adhesive on said web, removing the web so coated with adhesive and abrasive from said field and setting the adhesive, and collecting the uncoated abrasive grains, which pass through said field and are of a different grade from those coated for subsequent abrasive use.

7. A process of coating abrasives onto a reinforcing backing, comprising providing at least one electrostatic field adapted to coat a finer grade of abrasive and at least one electrostatic field adapted to coat a coarser grade of abrasive, passing an adhesively coated backing through the first-mentioned electrostatic field and then through the second-mentioned electrostatic field, passing abrasive grains having finer and coarser grades therein first through the first-mentioned field and then through the second-mentioned field and coating on the adhesively coated side of the backing by electrostatic means, thereby, at least one finer portion of abrasive grains and thereafter at least one coarser portion of abrasive grains whereby a composite abrasive coating is built up on the backing which is relatively free from finer grains that have been embedded between the exposed portion of the coarser grains, and then setting the adhesive to anchor the grains to the backing.

8. A process of grading comminuted material such as abrasive grains having finer and coarser portions intermixed therein, comprising establishing between spaced electrodes, an electrostatic field of alternating polarity of controlled frequency with the direction of force of said field having a component parallel to the force of gravity, conducting through said field separate means for removing therefrom, at least one finer graded portion of comminuted material introduced into the field and at least one coarser graded portion of such comminuted material, adjusting the voltage, the electrode spacing and the frequency of alternations of the polarity of said field in accordance with the grade and quantity of material to be separated as the finer graded portion of the material, and thereby moving a finer graded portion of the material to the first-mentioned material-removing means for removal therewith from said field, and removing on the second-mentioned material-removing means the coarser graded portion of the material not so separated by the electrostatic field, whereby the comminuted material fed to the electrostatic field is separated into at least one finer graded portion and at least one coarser graded portion.

9. A process of manufacturing coated abrasives, comprising providing between spaced electrodes, an electrostatic field of alternating polarity of controlled frequency, the direction of force of said field having a component parallel to the force of gravity, passing an adhesively coated foundation material through the said electrostatic field adjacent an upper electrode of said field with the adhesively coated side facing downwardly, feeding abrasive grains of variable size through said field below said adhesively coated foundation material and adjacent a lower electrode, adjusting the voltage, the electrode spacing and the frequency of the alternation of the polarity of said field in accordance with the grade and quantity of material that it is desired to deposit electrostatically upon said adhesive, and depositing thereby a controlled weight of a controlled grade of abrasive onto said adhesively coated side of said foundation material, removing the residual uncoated abrasive from said field and setting the adhesive to anchor the coated abrasive grains to the said foundation material.

10. Apparatus for coating comminuted material, such as abrasive grains onto an adhesively coated backing, comprising at least two pairs of electrodes, each pair of electrodes being spaced for the establishment of an electrostatic field therebetween which has a component of force parallel to the force of gravity, means for passing an adhesively coated backing in sequence through the first and second pairs of electrodes adjacent an upper electrode in each pair of electrodes, means for establishing an electrostatic field of alternating polarity between said first pair of electrodes, means for controlling the frequency of alternation of said field of alternating polarity and whereby a predominantly finer grade of comminuted material may be propelled to the adhesively coated side of said adhesively coated backing between the first pair of electrodes, means for establishing an electrostatic field between the second pair of electrodes such that a coarser grade of comminuted material may be coated electrically, and means for feeding comminuted material of variable size in sequence through the first pair of electrodes and then through the second pair of electrodes.

11. Apparatus for coating comminuted material, such as abrasive grains onto an adhesively coated backing comprising at least two pairs of electrodes, each pair of electrodes being spaced for the establishment of an electrostatic field therebetween which has a component of force parallel to the force of gravity, the electrode spacings gradually decreasing from a maximum at the beginning of the first pair of electrodes to a minimum at the end of the second pair of electrodes, means for passing an adhesively coated backing in sequence through the first and second pairs of electrodes adjacent an upper elec-

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trode in each pair of electrodes, means for establishing an electrostatic field of alternating polarity between said first pair of electrodes, means for controlling the frequency of alternation of said field of alternating polarity and whereby a predominantly finer grade of comminuted material may be propelled to the adhesively coated side of said adhesively coated backing between the first pair of electrodes, means for establishing an electrostatic field between the second pair of electrodes such that a coarser grade of comminuted material may be electrically coated, and means for feeding comminuted material of variable size in sequence through the first pair of electrodes and then through the second pair of electrodes.

12. A process of separating comminuted material having particles of different sizes therein into finer and coarser portions comprising establishing an electrostatic field of alternating polarity between spaced electrodes having free space for motion of particles between the electrodes, passing said comminuted material into said field, controlling the frequency of alternations of polarity of said field so that the average displacement of the finer particles per electrical impulse is substantially greater than the average displacement of the larger particles per electrical impulse and so that the average displacement of the larger particles per electrical impulse is substantially less than the free space distance between the electrodes, and whereby there is created in the field and adjacent one electrode, a zone containing a finer portion of comminuted material and relatively free from the coarser portions of comminuted material, removing the finer portion of comminuted material from this zone and collecting it for a subsequent use, and separately removing the coarser portion of comminuted material and collecting it for a separate subsequent use.

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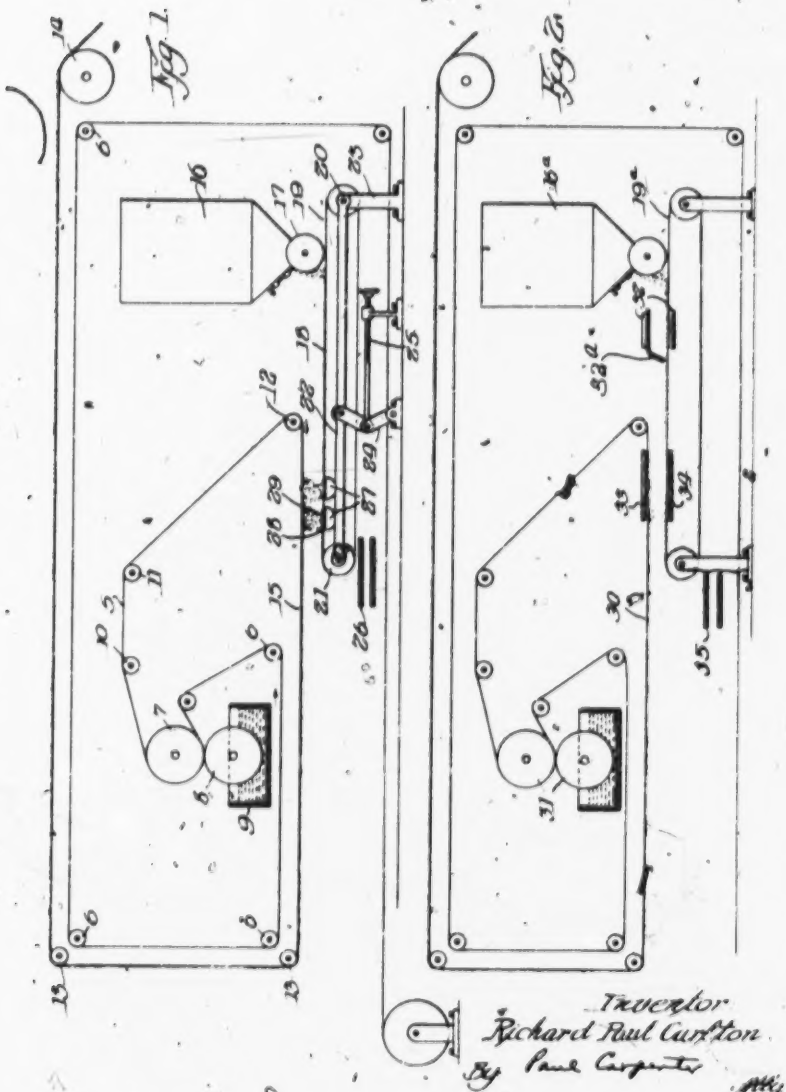
May 22, 1945. R. P. CARLTON 2,376,342

MANUFACTURE OF ABRASIVES

Original Filed Jan. 20, 1930 5 Sheets-Sheet 1



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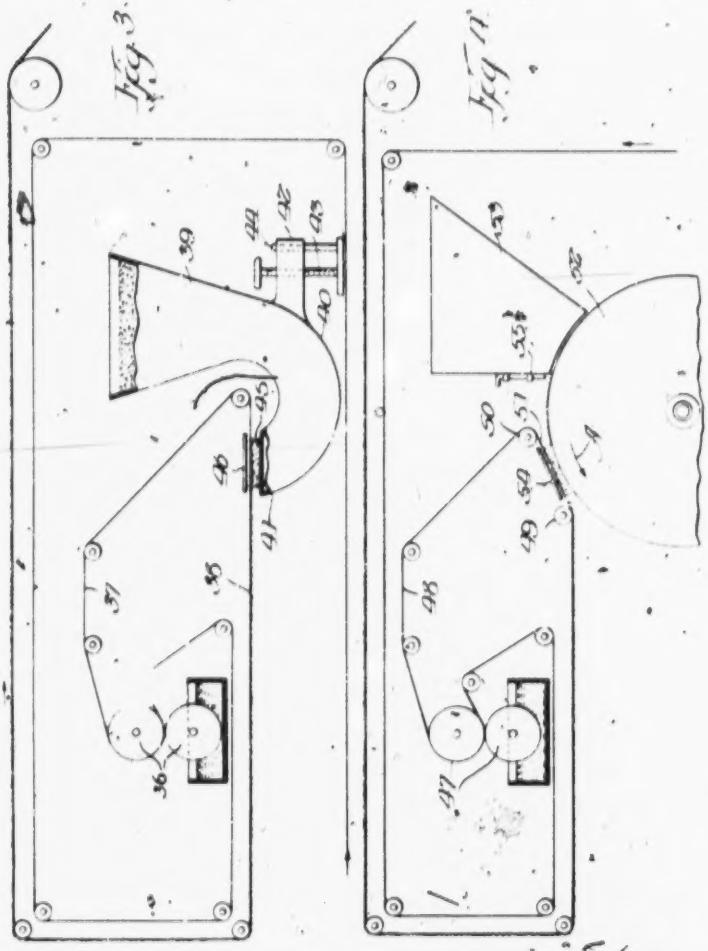
MANUFACTURE OF ABRASIVES

Original Filed Jan. 20, 1930 5 Sheets-Sheet 2



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MANUFACTURE OF ABRASIVES

Original Filed Jan. 20, 1930 5 Sheets-Sheet 3

Fig. 5

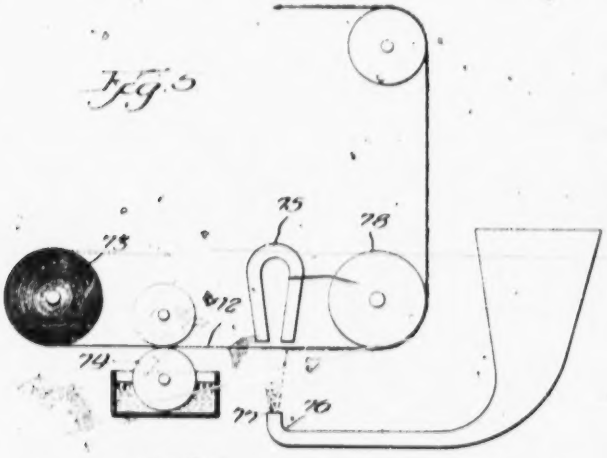

Fig. 6

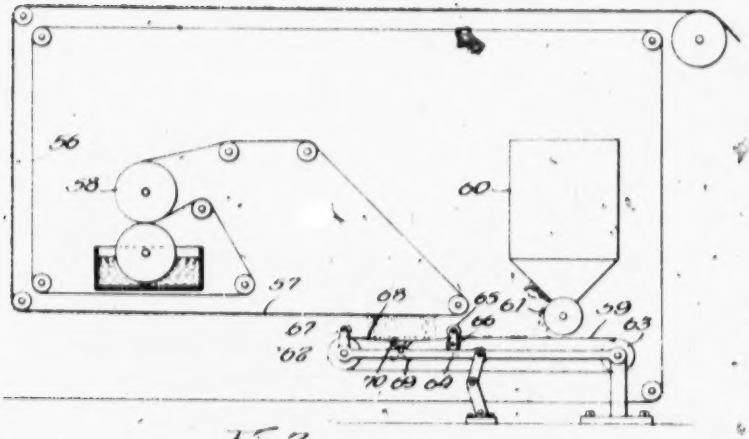

Fig. 7

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MANUFACTURE OF ABRASIVES

Original Filed Jan. 20, 1930 5 Sheets-Sheet 4

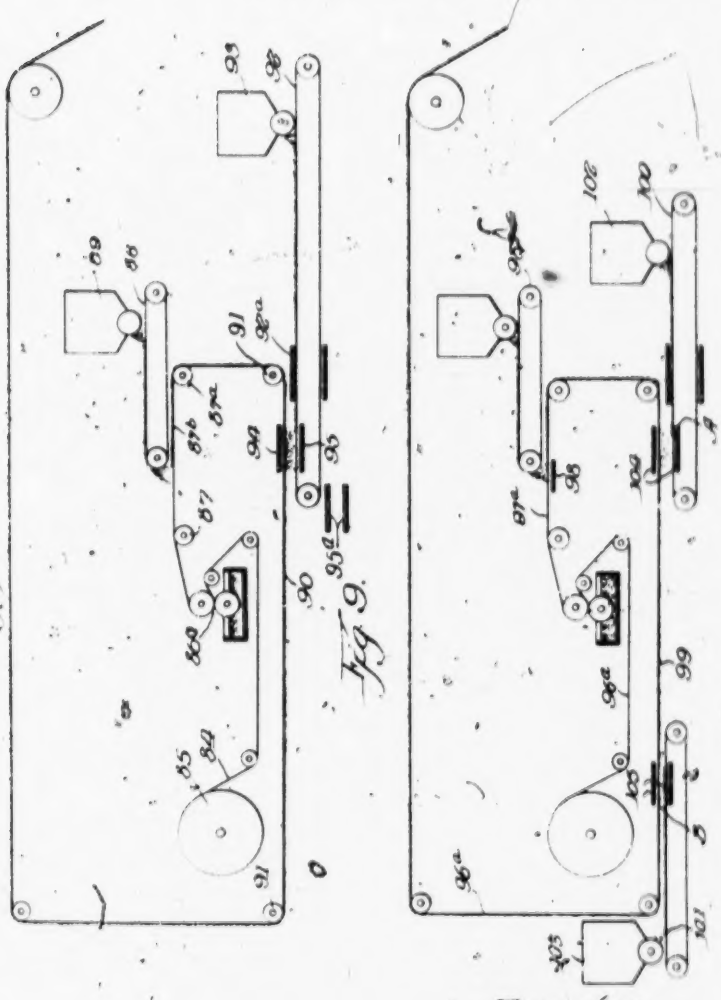

Fig. 9.

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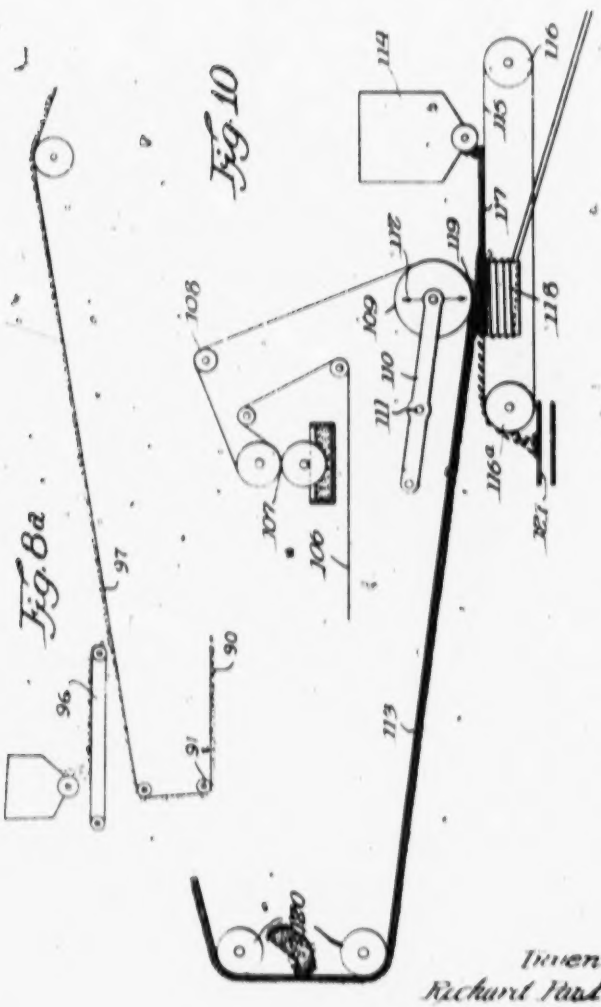
MANUFACTURE OF ABRASIVES

Original Filed Jan. 20, 1939 5 Sheets-Sheet 5



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[fol. 630]

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2,376,342

UNITED STATES PATENT OFFICE

2,376,342

MANUFACTURE OF ABRASIVES

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Original application January 28, 1930, Serial No. 422,065. Divided and this application July 8, 1941, Serial No. 401,484

8 Claims. (Cl. 117—17)

This invention relates in general to coated articles and to the art of coating, and more particularly to an improved method of and apparatus for applying pulverulent coatings to suitably adhesively coated surfaces, and while the invention finds particular utility in the art of making flexible abrasives, and is, therefore, described and illustrated for this purpose, it finds a wide field of utility for analogous purposes.

This application is a division of my copending application Serial Number 422,065, filed January 20, 1930, now Patent No. 2,318,570, granted May 4, 1943.

It is well known that in the art of making sandpaper, emery paper or cloth and similar abrasive articles, a flexible or in some cases, a rigid, backing of paper, cloth, wood or the like is employed, to which is applied a coating of an adhesive substance, such as animal or vegetable glue, or where a waterproof article is desired, the backing may be coated with any of the now well known waterproof adhesives of the Okie Patents 1,585,027, 1,585,028, of December 8, 1925, or 1,581,837 of April 20, 1926, for this purpose, and while the coating is still wet or unset, a suitable abrasive material such as garnet, corundum, sand or the like is applied thereto. The grains of abrasive substance are usually applied by gravity upon the upper adhesive coated surface of the backing, and they lie in the adhesive material in haphazard fashion due to the elongated nature of the abrasive particles, and in a large degree, the facets or cuttings edges of the individual grains or grits often lie flat upon or are embedded in the adhesive coating in such a manner that in some instances their best cutting edges never come into contact with the work or at best are brought inefficiently into contact therewith. The invention here has as one of its objects to measurably increase the number of grits whose longer or greater dimensions are in a plane perpendicular to the surface of the backing, thereby to present more efficiently the cutting edges to the work, and increase the cutting ability and life of the abrasive article.

It will be understood that in ordinarily depositing mineral, that is, pulverulent abrasive material solely under the force of gravity onto a backing, it acquires a velocity due to the action of gravity. As the grits pass through the intervening air space, there will be caused some change in their positions en route to the sheet or backing, but ordinarily neither the velocity given to the grits or the effect of the air on them is sufficient to cause them to become aligned so as to assume positions substantially perpendicular to the backing. It is, therefore, necessary that independent force be applied to the grits, and I have found that by passing the grits through a static field of electric energy or of electro-magnetic energy or by mechanically imparting this force to the grits a much greater number of the individual particles will assume erect positions on the backing, which will enhance its cutting ability. As will later appear, my invention, in its several forms, is capable of application for operation in conjunction with gravity methods of applying the grit, inasmuch as under certain conditions, and for some purposes, it is desirable to employ both gravity and one of the forms of my invention in conjunction in order to attain a desired form of abrasive article.

In carrying out this invention, I find it desirable to employ a conveyor for conducting the mineral at rest relative to the conveyor by relatively slow speed to a point adjacent to which the independent force is applied for projecting the particles of grit onto the backing. I find that by then applying this independent force, be it mechanical or electrostatic or electro-magnetic, I am able to impart a high velocity to the particle so that any force of gravity acting on the particle, whether in the same direction, in a counter direction, or in a direction angularly to that at which the force is applied, will be relatively small compared to this force applied. It is possible with the present invention to apply the force directly counter to gravity, that is, by bringing the grits beneath the backing or by applying the force in some other direction as long as the force of gravity and the effect of air is reduced below a point which will interfere with the result desired, namely, the projection of the grits with their longitudinal dimensions ultimately perpendicular or substantially so with respect to the backing.

The principal objects and advantages of this invention reside in the provision of an improved abrasive coated article, such, for example, as sandpaper, emery cloth, or the like, wherein the abrasive grits or grains lie in position on the backing for increasing the cutting effect and durability of the abrasive article; the provision of an improved abrasive article wherein the abrasive grits are disposed so that their cutting facets are presented in position to more efficiently engage the work and thereby produce a sharper article; the provision of an improved abrasive article wherein the abrasive grains or grits are applied thereto with their longer or greater dimension substantially perpendicular to the plane of the backing;

the provision of an improved abrasive article which may be flexible or rigid, as desired, and which may or may not be made waterproof, that is, suitable for employment in a water abrading operation.

This invention further includes as objects and advantages thereof, the provision of an improved method of and apparatus for manufacturing abrasive articles; the provision of an improved method of and apparatus for applying pulverulent material to one surface of a backing irrespective of the force of gravity, that is, against the normal tendency of the force of gravity; the provision of an improved method of and apparatus for propelling a pulverulent material, such as a grit or an abrasive grain, against an adhesive coated surface; the provision of an improved method of and apparatus for the purpose set forth and including electrically operated means for acting on an abrasive grain or pulverulent material and causing it to advance onto the adhesive coated backing irrespective of the force of gravity; the provision of an improved method of and apparatus for causing the particles of pulverulent material to impinge upon and assume a position in the adhesive coated surface substantially normal or perpendicular to the surface of the backing; the provision of an improved method of and apparatus for propelling a pulverulent material onto a moving sheet in a direction transversely to the plane of movement thereof and in a direction substantially counter to gravity; the provision of an improved method of and apparatus for making abrasive articles, such as sandpaper and the like, which includes the application of a grit to the under side of the backing; the provision of an improved apparatus which includes means for feeding and applying a pulverulent material counter to the force of gravity and simultaneously with movement of the backing; the provision of an improved means for moving a web of paper and applying an adhesive thereto and including means arranged below and for operating synchronously with for applying a pulverulent material to the under side of said moving backing; and the provision of an apparatus of the character described wherein improved electrostatic or electro-magnetic means may be employed, acting on the abrasive material and causing it to move at an accelerated speed toward the sheet so as to cause it to impinge thereon in the adhesive coating and thereby present the cutting edges of the abrasive grits away from the surface of the backing and thus increase the cutting ability and life of the abrasive article.

I have also found my invention useful as a modifying step in the employment of the conventional gravity process for applying grit in the manufacture of sandpaper or other abrasive and, therefore, additional objects of this invention reside in the provision of an improved method of interposing an additional step which will apply abrasive grains either before or after the application of grits by gravity in the usual manner, it being understood that the step of applying grit irrespective of gravity, by an electro-magnetic or electrostatic means may be employed somewhere in the process of manufacture, the essential purpose being to increase the number of grits whose cutting facets are presented away from the backing and thereby to enhance the cutting ability of the finished article.

The apparatus of this invention includes a number of alternative forms for mechanically or electrically carrying out the steps of the process, and to this end is provided an improved pneumatic means and improved vibrator structure for mechanically propelling the pulverulent material and improved electro-magnetic structure for acting on the mineral and causing it to move in a cloud toward the adhesive coated surface of the moving web or backing.

The foregoing and such other objects and advantages as may appear or be pointed out as this description proceeds are attained in the structures illustrated in the accompanying drawings in which:

Figure 1 is a schematic view illustrating one form of apparatus for carrying out the process of this invention;

Figure 2 is a view similar to Figure 1 of an alternative form of the invention;

Figures 3, 4 and 5 are further alternative forms of the invention which include the electrical feature;

Figure 6 is a further alternative form of the apparatus of this invention of employing mechanical vibrating means;

Figure 7 is an enlarged schematic view illustrating a portion of an abrasive article made in accordance with this invention;

Figures 8 and 9 are additional alternative forms of apparatus for carrying out further steps of the process of this invention; and

Figure 8a is a fragmentary schematic view of another alternative form of apparatus;

Figure 10 is a further alternative form of apparatus for carrying out one of the methods of this invention.

The method of the present invention includes as steps thereof the feeding of a web or strip of paper or other fabric at a predetermined rate of speed, applying an adhesive substance to the under side of the sheet, or applying the adhesive coating to one side and then moving the sheet with the coated side out, and simultaneously with the movement of the coated sheet, causing a grit or abrasive material to be applied to the side. The sheet or web of paper may be moved so that the adhesive coated side is either presented downwardly or at any angle thereto. The movement of the abrasive grains onto the under side of the backing is done irrespective of the force of gravity and, in fact, directly counter to gravity, and preferably done by imparting relatively high velocity to the abrasive material, thus causing it to impinge upon the adhesive coating. In view of the fact that the abrasive grains are projected through an intervening space from a suitable carrier onto the adhesive coated side irrespective of or counter to the force of gravity, the grains, which are usually somewhat elongated, will assume a position in transit so that the longer dimension thereof will take a position normal to the surface of the backing, thus causing the grains to "stand" on the surface rather than lie flat in greater percentage than when they are deposited by gravity. It is to be understood that this movement of the grains and deposition of them on the coated surface may be carried out in a number of ways, either by vibration, by an air blast, or by electrostatic or electro-magnetic means.

In the alternative forms of this invention later to be described, the method involved includes combining a gravity deposition of mineral on the adhesively coated moving backing with the step of applying the grits irrespective of gravity, this being particularly useful in some

[fol. 632]

of the heavier grits wherein it may be found that the force susceptible of application by an electrostatic or an electro-magnetic means is not sufficiently active on the available area of the individual grits to cause an entirely satisfactory result or to move enough of the grits into the sheet to attain the desired end. In this invention it may be required to apply some of the grit by gravity and later apply some of the grit by one of the methods of this invention or vice versa, but, in any event, the number of grits in the entire finished article which stand erect on the backing will be measurably increased over the ordinary methods heretofore employed for depositing grit on a backing for forming an abrasive article.

This invention produces a very satisfactory piece of sandpaper in which the cutting ability is measurably increased and by the deposition of the grains of sand or grit irrespective of the force of gravity. It is possible to produce an orientation of the mineral as desired and to control the thickness of the abrasive coating much more readily than where gravity alone is relied upon or employed for depositing the grains on the sheet.

The apparatus of this invention may take any one of the forms shown in the drawings, and in the form of the invention shown in Figure 1, air pressure is resorted to for producing the mineral cloud and for projecting the mineral onto the moving web.

Referring now more particularly to Figure 1, the flexible backing 6 of paper or cloth or other fabric is drawn or fed over a series of rollers 7, 8, and over one of a pair of the squeeze rollers indicated at 7, the other roller 8 of said pair being in contact with an adhesive material contained in a tray or tank 9 by which an adhesive coating is applied to one side of the moving web. After receiving the adhesive coating, the web 6 is trained over rollers 10 and 11 and is brought back over a roller 12 so that the adhesive coated surface of said web is presented downwardly. The web may then be trained over rollers 13, 14, and fed to a suction drum 15, whence it passes into festoons for drying.

The mineral is supplied from a hopper 16 and a conventional outlet 17 which feeds a layer 18 of mineral to a moving conveyor 19. This conveyor 19 is preferably porous and passes over the feeding rollers 20 and 21 and is adapted to move at a suitable rate of speed to supply a sufficient quantity of abrasive grain. In some cases, it has been found advantageous to move the conveyor at a speed substantially the same rate of speed as the web 6, although these speeds are, of course, variables. The rollers 20 and 21 are mounted in the ends of a suitable frame 22, and this frame may be raised and lowered so as to vary the distance between mineral conveyor 19 and the moving web 6. This frame 22 may be supported freely at one end, as indicated at 23, and the other end may be raised and lowered by a toggle arrangement 24 activated by a threaded rod 25. Below the conveyor 19 and at the movable end thereof, that is, adjacent to the web 6, there is provided a second conveyor 26 which serves to conduct away excess mineral which flows over the end of the conveyor 19 and which may be returned in any suitable manner to the mineral hopper.

Below the upper flight of the conveyor 19, there are provided two air troughs 27. These air troughs are provided with flat upper walls 28, having slots 29 therein, said slots extending across the width of conveyor 19 and the troughs themselves being connected to a suitable source of air under pressure.

These troughs form in effect elongated jets or nozzles and when so placed below the conveyor belt or frame 22, a small quantity of air is emitted at high velocity which passes through the porous belt or conveyor.

It will be understood that when a blast or blasts of air are delivered from the troughs 27, this blast of air passes through the porous conveyor 19 and blows the mineral from the conveyor against the under side of the flight 18 so that the mineral is caused to strike into the adhesive at a relatively high velocity and become impinged therein. Owing to the projecting of the mineral in this manner through the intervening air space, the individual particles of grit or abrasive material are caused to assume a position parallel to their trajectory, that is, with their longer dimension perpendicular to the surface of the flight 18. In view of the fact that most of the particles of mineral are somewhat elongated, due to the manner of production of the same, they will naturally assume this position in movement from the conveyor 19 to the adhesive coated surface of the backing. As they arrive at the adhesive material, they impinge, themselves thereon and will thus stand erect in the adhesive, thus forming a sharper contour for abrasive purposes. By varying the rate of speed of the moving backing relatively to the speed of the conveyor and by varying the distance between the conveyor and the backing and the velocity of the air stream, and by increasing or reducing the number of such jets and the quantity of adhesive applied, any reasonable desired thickness of grit layer may be produced during the process and without stopping the apparatus. It will be understood that the excess mineral carried by the conveyor may be dumped into the conveyor 26 and returned by any suitable means to the hopper 16.

Referring now to Figure 2, there is provided the same general arrangement of moving backing, having the flight 30 adhesively coated from the squeeze rollers 31.

Below the flight 30 there is provided a mineral feeding conveyor 18a, receiving pulverulent material from the hopper 18a.

The conveyor 19a is mounted for movement toward and away from the flight 30 similar to the conveyor 19 and, therefore, this structure has not been shown in Figure 2.

As the mineral flows from the hopper 18a it does not always assume a smooth or even distribution on the conveyor 19a, and, therefore, it may be desirable to provide a pair of charged electrodes 32, one arranged above and one below the conveyor 19a, for the purpose of spreading the mineral evenly on the conveyor belt. The conveyor 19a in this instance may be non-porous.

When charged electrodes are put in this position they act in principle the same as the charged electrodes used for coating the mineral on the backing. An electrical charge or difference of potential is set up between the electrodes 32. The voltage or difference in potential between those electrodes is maintained great enough to produce a strong electrostatic field, but not so great as to break down the insulation between the plates which insulation may be the dielectric strength of the air or the dielectric strength

of the air plus the dielectric strength of any insulating material which may be used to wrap the electrodes.

As the mineral on the conveyor enters the static field between the plates the mineral particles take on the charge of the lower plate, and are repelled to the upper plate where they lose their charge and take on the opposite charge of the upper plate. At this point they are repelled to the lower plate. Since new mineral is being conveyed by the conveyor into the field continuously the static fields soon become supersaturated with mineral particles, and an equilibrium is reached where as many particles are thrown out of the static field as are brought in by the conveyor. By having a down-turned end 23a of the upper electrode the mineral particles that are thrown out of the static field are deflected evenly on the conveyor belt so that a smooth coating of abrasive grit is first placed on the conveyor.

The use of an electrostatic field for getting a smooth coating of mineral on the conveyor belt is not necessary to the invention but is an additional means of obtaining evenly distributed abrasive coatings, and is also a means for avoiding the use of any excess mineral on the conveyor. When the mineral is evenly coated on the conveyor at the time it is being coated, streaks, thin spots, etc., in the finished product are reduced.

At the same approximate point at which troughs 27 are provided in Figure 1 there are here provided electrically charged electrodes 33 and 34, the electrode 34 being located below the upper flight of the conveyor belt 18a and electrode 33 being disposed above the flight 30 of the backing. A sufficient difference of potential is maintained at electrodes 33 and 34 to produce a strong electrostatic field, similarly to that referred to above. This electrostatic field moves the mineral from the belt 18a to the underside, which is the adhesive coated surface of the flight 30.

As the mineral enters the electrostatic field between the electrodes 33 and 34 it becomes charged with the charge of the lower plate, and is here propelled to the upper plate 33.

It will be observed that in this method of coating the mineral is applied by a force other than gravity. In all other methods of coating sandpaper, known to me, the velocity of the particle is either in whole or part given to it by the force of gravity. In the case of this electrostatic coating the particles are oriented in the electrostatic field so that there is a tendency for the long dimension of the mineral to be perpendicular to the electrode plates, and also perpendicular to the web 30, which is being coated. The finished sandpaper product, therefore, contains a substantial percentage of the particles of mineral standing on end rather than laying flat, thereby increasing the cutting properties of the abrasive article.

Excess mineral is dumped onto the conveyor 35, whence it may be returned to the hopper 18a.

Referring now to the alternative form of the invention shown in Figure 3, there are provided the squeeze rollers 36 which apply adhesive to one surface of the moving paper web 37, and the adhesive coated surface thereof is presented downwardly in the flight 38.

In this instance there is provided a hopper 39, having a curved outlet spout 40 whose outlet 41 is presented below the moving web 38. The hopper may be provided with a bracket 42 whereby to receive a threaded member 43, said bracket engaging a guide post 44. In this manner, the hopper may be raised or lowered so as to vary the distance of the outlet 41 from the flight 38 of the backing. A suitable screen 46 may or may not be provided over the outlet so as to cause the distribution of the mineral contained in the hopper. In this instance, the mineral flows by gravity to the outlet 41, but does not pass from the outlet to the adhesive coated backing by gravity, but under the effect of the static charge established between the electrode 46 and the hopper or the screen 46 of said hopper.

The operation of the invention here is much like that of Figure 2, the screen 46 serving the purpose of distributing the mineral and at the same time preventing the large body of mineral in the hopper from forcing it against the coated surface of the backing.

Referring now to the form of the invention shown in Figure 4, there is provided the adhesive coating rollers 47, applying an adhesive coating to one surface of the moving web 48. This web 48 is trained over rollers 49 and 50 so that flight 51 thereof between said rollers is presented in a plane tangential to the surface of a conveyor drum 52 whose lineal velocity is sufficient to furnish the required amount of mineral. This drum is fed from a hopper 53 and forms one electrode of the electrostatic system. The other electrode is indicated at 54 and is disposed above the flight 51. As mineral issues from the gate 55 of the hopper, the drum rotating in the direction of the arrow A, the mineral is carried to a point adjacent to the flight 51, whereupon the electrostatic charge set up between the drum 52 and the electrode 54 will cause a projection of the mineral from the drum onto the coated surface of the flight 51.

Referring now to the alternative form of the invention shown in Figure 5, there is employed here electro-magnetic means or a permanent magnet means for moving the grits toward the adhesively coated web. The adhesively coated web is shown at 72 and is fed from a roll 73 over an adhesive coating roller 74. The horizontal flight of the web 72 passes beneath magnet 75 which may be either an electro-magnet upon which a variable voltage may be imposed or a permanent magnet.

Immediately below the magnet 75 and the flight 72 of the web, there is provided a source of supply for the mineral, that is, the abrasive material, indicated at 76. This source includes an outlet 77, and the distance between the outlet 77 and the moving web 72 may be varied as desired, or the intensity of the electro-magnet, where one is employed, may be varied for changing the thickness of the abrasive coating. The web passes over an idler 78 whence it is led to festoons not shown.

Referring now to the form of the invention shown in Figure 6, the moving web 86 is trained over a series of rollers similar to the arrangement shown in Figures 1 and 2 so that a horizontal flight 87 of the paper backing is provided, having an adhesive coating on the under side thereof. Squeeze rollers 88 engage the paper backing for applying an adhesive thereto.

In this form of the invention, a mechanical vibrating means is provided which serves to propel the mineral, that is, the grit, from the grit-feeding conveyor 90, which latter receives mineral from the hopper 89, having a gate 91. The conveyor 90 is trained over rollers 92 and 93

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mounted in a suitable frame 94, which latter may be mounted for adjustment toward and away from the flight 87 similarly to the conveyor 19 of Figure 1. The conveyor 90 extends below and is separated from the flight 87 of the paper web and travels at substantially the same speed as the paper web.

The conveyor 90 passes between sets of pinch rollers, one above and one below the upper flight of the conveyor 90, as indicated by 95 and 96, and also beneath a pinch roller 97 which bears on the roller 93. The pinch rollers 96 and 96 tend to distribute the mineral evenly over the surface of the conveyor and are so spaced from the rollers 92 and 97 that the portion of the belt 90 between the rollers 95 and 96, and 92 and 97 is permitted to be slack, whereas the remaining part of the conveyor is substantially taut. This arrangement tends to limit the vibration of the conveyor belt to the zone of application of the mineral to the paper backing, as indicated at 98.

Beneath the portion 98 of the belt 90, there is provided a revolving batter 99 operating on a shaft carried in suitable bearings in the frame 94 and provided with a plurality of radial arms 78 which upon rotation rigidly strike the under side of the portion 98 of the belt, thus throwing or projecting the mineral content thereof against the under side of the adhesive coated paper backing, much in the manner in which the air stream blows the mineral or grit against the paper backing as shown in Figure 1. The batter 99 may be driven in any desired manner from a separate source of power or may be connected suitably with the rollers driving the belt 90, but geared to operate at a greater rate of speed. The rollers 96 and 96 and the roller 97 are separately driven from the belt 90 so as to produce the tautness in the belt, except the flight of the belt indicated at 98.

In Figure 7, there is illustrated an article made in accordance with the present invention. The backing is shown at 80 to which an adhesive coating 81 has been applied, and the grits, greatly enlarged, are indicated at 82, and it is noted that they stand on end in the adhesive coating, thus causing their sharper edges to project beyond the upper or outer surface of the coating, thereby enhancing the cutting ability and increasing the life of the abrasive article. While the article shown in Figure 7 is purely schematic, it will be understood that the mineral actually does take a position substantially normal to the backing and, while all of the grits may not take this position, a large number of the same do, and the cutting qualities of the abrasive article are thus greatly increased. Furthermore, by so disposing the grits, it permits of the application of an additional sizing coat or coats to the back and to the front or cutting face of the abrasive material without completely burying the grits and as a thicker coat of adhesive may thus be employed on the cutting face of the abrasive material, the engagement of the adhesive material with the abrasive material is greatly enhanced, thus further tending to increase the life of the abrasive article. Such a sizing coat is indicated at 83.

As previously pointed out, where the electrostatic or electro-magnetic methods are resorted to in some of the coarser grades of abrasive devices made, it may be found that the electrostatic or magnetic field into which the particles are conducted may not exert on each individual particle sufficient force to cause proper orientation of the particles, for the reason that the electrostatic effect is substantially proportional to the area of the particle, and the coarser the particle, the smaller the area of effect per weight. Therefore, as larger grits or sizes of particles are employed, increased force is required to move the particle, and for some purposes, insufficient increase in force results because of the reduced area per weight. Therefore, in such cases, a form of the invention, as shown in Figure 8, may be resorted to wherein the mineral is applied to the adhesively coated backing in part by gravity and in part by electrostatic or electro-magnetic means.

In view of the fact that the electrostatic and electro-magnetic means may for some purposes be alternatively employed, I have illustrated in Figure 8 merely the electrostatic elements, though it will be understood that the electro-magnetic means of Figure 5 may be employed in the same manner.

Referring in detail to Figure 8, I have illustrated a web of paper 84 coming off a roll 85 and passing through an adhesive coating device illustrated in general at 86. The web 84 is thence trained over rollers 87, 87a, so that it has a substantially horizontal flight 87b, which receives grits in the desired amount from an ordinary conveyor 88, said conveyor receiving grits from the hopper 89. The web of paper thence is carried downwardly to a horizontal flight 90 by the provision of rollers 91, 91, and adjacent one end of this flight, I provide the conveyor 92 receiving additional grits from the hopper 93, which may be adjustably mounted similar to the conveyors hereinabove described, said conveyor 92 passing beneath the flight 90 of the paper web. As the web passes over the rollers 87a and 91, a quantity of the mineral deposited from the conveyor 88 onto the web will drop off, and, for conveying away this excess mineral, I provide a transversely running conveyor 92a arranged between the flight 90 and the conveyor 92. Beneath the upper flight of the conveyor 92 and above the flight 90 of the web 84, I provide electrostatic electrodes 94 and 95, or may provide an electro-magnet similar to that shown in Figure 5 which will cause grit coming from the hopper 93 to be applied counter to the force of gravity onto the under surface of the flight 90. A conveyor 96a may be employed for carrying off the excess mineral from the conveyor 92.

In the operation of this form of the invention, it will be understood that a desired proportion of mineral applied by gravity to that applied by force other than gravity may be determined by actual operation so that the desired quantity of the abrasive grits is properly applied to the paper web.

It may be necessary in some of the very coarse grains to additionally apply grit to the moving web, and this may be done by providing an additional conveyor similar to that indicated at 92 and additional electrodes, or may be accomplished by additionally applying by gravity grits at the point indicated at 96, this arrangement being shown in Figure 8a and the grits being applied to an upper flight 97 of the paper web just before it passes on to the festoons.

Figure 9 illustrates the alternative forms suggested in connection with Figure 8, that is, wherein electrostatic or electro-magnetic means, or any other means counter to gravity, is employed for applying the grits, and in Figure 9 the paper web is indicated at 96a having a horizontal flight 97a disposed below a conveyor 98a. In this instance, the grits are deposited from the conveyor

98a by gravity, and the orientation of the grits is assisted by a plate electrode 96. The paper web may then be carried in position so as to provide a horizontal flight 99, and an electrostatic or electro-magnetic or other grit applying means for applying grit counter to gravity may be employed at one or more points as indicated at A and B, wherein the conveyors 100 and 101 convey grit from suitable hoppers 102 and 103, and electrodes 104, 104 and 105, 105 serve to apply the grit.

Referring now in detail to Figure 10, there is further illustrated there an apparatus for applying the grit to the adhesively coated backing by an electro-magnetic means. In this form of the invention a moving web is provided indicated at 106, this web being a flexible strip of paper which is suitably adhesively coated by a mechanism indicated generally at 107.

The moving web thus adhesively coated is carried over a roller 108, thence over a roller 109, said roller 109 being mounted on a shaft carried in a bearing arm or arms 110 pivotally mounted at 111, whereby the roller 109 may be raised and lowered in the substantially vertical plane of the arrows 112, thus permitting the lower flight 113 of the paper web to be elevated or depressed, as the case may be.

Mineral is deposited from a hopper 114 onto a conveyor 115 trained over rollers 116 and 116a, the upper flight 117 of said conveyor passing beneath the roller 109 and the moving web and conveying mineral, that is, the grit, to a point adjacent to the roller 109.

Preferably immediately below the axis of the roller 109 and below the upper flight 117 of the conveyor 115 I provide an electro-magnet 118 which is so mounted that its magnetic flux passes through the conveyor and causes the mineral particles to stand erect, as indicated at 119, as they move along with the upper flight of the conveyor. While the mineral particles are thus standing erect they come into contact with the adhesively coated side of the paper backing and are thus picked up by it and conveyed away, the backing being trained over rollers 120 and carried to the festoons similarly to the other forms of the invention. It will be observed that the angularity of the lower stretch 113 of the paper web is such that it lies upwardly to the conveyor 115. In this way the particles of grit adhering to the paper are not knocked down by other particles remaining on the conveyor, it being understood that the grit is fed somewhat in excess of the required amount so that an adequate amount will be deposited on the adhesively coated side of the backing. The excess mineral drops off the conveyor 117 and is carried to a collecting means by a conveyor 121.

It will be understood that by varying the amount of mineral fed from the hopper, the strength of the electro-magnet, that is, the strength of the flow current transferred, and the position of adjustment of the roller 109, the assembly may all be properly correlated for obtaining the desired grade of finished article.

It may be desirable that a certain amount of pressure be exerted on the erect particles of mineral so as to cause them to impinge upon the adhesively coated side of the paper and thus, by manipulation of the arms 110, an adjustment of the pressure of the roller 109 may be attained.

It will be understood that while the electrostatic and electro-magnetic means for exerting counter to gravity are illustrated in Figures 8 and 9, the mechanical means hereinabove described may be conveniently employed in these locations without departing from the spirit of the invention. However, the reason the electro-magnetic and electrostatic elements are particularly shown here is that the difficulty of counter coating successfully with the coarser grains is more likely to arise with these elements than with the vibrator or air blast heretofore described.

I wish to point out that where the expressions "electro-magnetic" and "electrostatic" are employed in the specification, I refer to the employment as well of a permanent magnet or some other form of static charge or magnetic charge which will perform the function.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is:

1. The method of manufacturing an abrasive article having a backing and a grit layer, which includes as steps thereof applying an adhesive to one side of the backing, bringing the coated side of the backing into proximity to a quantity of grit, providing an electrical force acting on the grit for causing it to stand erect in relation to the backing material, and bringing the grit while thus erect into embedding contact with said adhesive by a differently applied mechanically embedding force.

2. In the method of making sandpaper or the like, the steps which comprise adhesively coating a web, directing said web with the adhesively coated surface downward and presenting the same adjacent a surface over which a layer of abrasive particles have been distributed, synchronizing the movement of the web and the distributed layer of abrasive and then transferring the abrasive to the adhesive.

3. In the method of making sandpaper or the like, the steps which comprise adhesively coating a web, directing said web with the adhesively coated surface downward and presenting the same adjacent a surface over which a layer of abrasive particles have been distributed, synchronizing the movement of the web and the distributed layer of abrasive and then transferring the abrasive to the adhesive by contacting the adhesive with the abrasive and removing the abrasively coated web from the zone of contact.

4. In the manufacture of granular coated webs, the method comprising positioning from a layer thereof in a deposition zone elongated granular particles upon an adhesive coated web with the major axes of the particles substantially uniformly oriented at an angle with respect to the surface of the web by moving the web into the deposition zone where said web is mounted in a position to face downwardly while in said zone, and supporting the freshly coated web with respect to the horizontal with the particle coated side down and in a position to have the particles thereof clear the layer in the deposition zone.

5. In the manufacture of granular coated webs, the method comprising positioning from a layer thereof in a deposition zone elongated granular particles upon an adhesive coated web, with the major axes of the particles substantially uniformly oriented at an angle with respect to the surface of the web by moving the web into the deposition zone where said web is mounted in a position to face downwardly while in said zone, orienting substantially all of the particles with their axes substantially in parallelism with each other and substantially normal with respect to the surface of the web and supporting the freshly

[fol. 636]

coated web with respect to the horizontal that the oriented particles hang vertically downward and in a position to have the particles thereof clear the layer in the deposition zone.

6. In the manufacture of abrasives upon a downwardly faced adhesive backing, the steps which include directing, depositing and orienting abrasive particles to form an abrading surface by subjecting the particles, during attachment thereof to the backing, to the combined actions of a contacting mechanical embedding force and an electrical force.

RICHARD PAUL CARLTON.

Certificate of Correction

Patent No. 2,376,342. May 22, 1945.

RICHARD PAUL CARLTON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 28, for "substance" read *substances*; line 33, for "cuttings" read *cutting*; page 2, second column, line 30, strike out "and" after "invention;" and insert the same after "apparatus;" in line 32; page 3, first column, line 7, for "into" read *onto*; line 12, for "whch" read *which*; and second column, line 30, after the syllable "pinge" strike out the comma; page 5, second column, line 4, for "gits" read *grits*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 22nd day of October, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.

[fol. 637]

IN UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA,
INDIANAPOLIS DIVISION

Defendant's Exhibit 5A.

PAGE 10 OF APPLICANT'S AMENDMENT FILED JUNE 28, 1945.

It is submitted that the Darrah and Pugh patents cannot be properly aggregated to build up a hypothetical anticipation of claims 7, 8, 9, 31, and 32. The spray of Darrah is discharged from the nozzle 4 through the opening in an oppositely charged element 8. In Pugh, the spray from gun 45 passes through an opening in a similarly charged element 10. Obviously, the spray-surrounding element cannot be charged both oppositely to the spray, as in Darrah, and similarly to the spray, as in Pugh. If the hypothetical aggregation is to include both Darrah's electrode 8 and Pugh's booth-wall 10, will the booth-wall be at the same potential as the electrode, will it be at the same potential as the nozzle, or will its potential differ from both? And what of the articles to be coated—will their potential be that of the annular electrode, that of the nozzle, or different from both? The answers to such questions are not found in the references, and it is therefore not apparent how the aggregation is to be effected. In such circumstances, it is submitted that the rejection on Pugh and Darrah is not well founded and that claims 7, 8, 9, 31, and 32 are allowable.

In connection with the rejection of claims on Pugh and Darrah, it is to be noted that applicants' apparatus employs a single electrostatic field to perform two functions—the production of atomization and the propulsion of the atomized particles to the article being coated. Applicants are not claiming broadly any and all devices in which liquid is electrostatically atomized and then electrostatically propelled to and deposited upon an article to be coated.

[fol. 638]

PAGES 14 AND 29 OF APPLICANT'S BOARD OF APPEALS BRIEF FILED JANUARY 5, 1951.

(a) increased from 80 or 100 to 200 the number of panels coated per gallon of paint used;*

(b) resulted in a coating "noticeably better than that obtained" with air-atomized, electrostatically deposited paint; and

(c) could be performed "in the open factory building and without the necessity for an enclosing booth or any exhaust system" such as was necessary in the other process "to carry away the overspray."

Helmuth, Juvinall, and Simmons are, as shown by their respective affidavits, well qualified to determine and compare the efficiencies of various painting methods. Their affidavits testify that procedures employing the apparatus and method of this application are markedly more efficient than prior spray-painting procedures. The affidavits also establish that the high paint-utilization efficiencies attainable with applicants' method and apparatus permit the elimination of paint spray booths and air-exhaust systems.

The Essential Novelty of the Invention.

The heart of applicants' invention lies in the concept of employing a single electrostatic field which acts as the sole agent to atomize paint, disperse the particles formed by

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* It is not contended by applicants that the increased paint-utilization efficiency obtained by Simmons is representative of what is to be expected in the coating of panels and similar articles. Nevertheless, his affidavit does reflect the experience of one independent user. Each of the panels coated by Simmons had a multiplicity of perforations; and it may be that the presence of those perforations explains the exceptional improvement in efficiency which he obtained.

atomization, and deposit those particles on the work. That concept is unquestionably novel. We have here no mere substitution of one old element or step for another, no mere change of proportion, size, or degree, producing only the expected and obvious result. Instead, we have an attack from an entirely new angle on a problem of long standing. The results obtained, by virtue of their very magnitude, are entitled to be considered unobvious and unexpected.**

[fol. 639] Claims 61 and 65 distinguish specifically from Huebner '194 by requiring the article and its support to move through a considerable distance in unvarying relationship, whereas in Huebner the paper support 16 or 116 never moves with the paper.

Claims 61, 65, 67, and 78 describe a construction in which the lines of force of the field sweep the surface of the article being coated, a requirement whose significance is brought out above in connection with method claim 76.

Patentability.

There can be no argument as to the novelty of the appealed claims. Their patentability, as the wording of the rejection indicates, hinges upon whether their subject matter involves invention.

The heart of applicants' invention lies in the spray-painting of articles of manufacture by the use of a single electrostatic field which will both atomize a liquid coating material, disperse the atomized particles, and then deposit those particles on the surface which is to be coated. The references of record can be searched in vain for any disclosure or suggestion of such a coating process. The Examiner points out how prior-art structures might be modified to render them anticipatory; but in so doing the Ex-

** Eibel Process Co. v. Minnesota etc., 261 U.S. 45, (20% increase in efficiency); Ex parte Alexander, 72 PQ 524; Ex parte Taussig, 50 PQ 394.

aminer is clearly exercising ex post facto wisdom. No suggestion of the proposed changes can be found within the four corners of any reference, where it must be found to negative patentability.

"Obviously," the Examiner states, "liquid coating material could be supplied through the tube 32 in Meston's Fig. 5 and through the pipes 71 in Figs. 18 and 19." But, bearing in mind that Meston was concerned entirely with the deposit of particled solid material which had to be supplied to the field by suspending it in a carrier gas stream, who would think of running liquid through Meston's pipes?

[fol. 640]

IN UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA,
INDIANAPOLIS DIVISION

Defendant's Exhibit 5B.

AFFIDAVIT OF GILBERT ISGRIGG FILED MARCH 20, 1953.

STATE OF INDIANA,
COUNTY OF BARTHOLOMEW, } ss.:

Affidavit.

Gilbert Isgrigg, of Columbus, Indiana, being first duly sworn, deposes and says as follows:

I am an engineer in the employ of Hamilton Manufacturing Corporation, of Columbus, Indiana, manufacturer of the "Cosco" line of metal chairs, stools, step stools, and utility tables.

The utility tables manufactured by my employer have sheet-metal tops measuring either 16 x 22 inches or 17 x 24 inches, and each table is provided beneath the top with one or two shelves of corresponding size.

The tops and shelves of the tables mentioned are finished by painting them; and my duties for my employer include the selection and supervision of the equipment and methods used in painting the tops and shelves of utility tables.

For a period beginning in March, 1948, and continuing through the present, the tops and shelves of Cosco utility tables were painted with the use of electrostatic painting equipment under license from Ransburg Electro-Coating Corp. of Indianapolis, Indiana. Such equipment embodied a conveyor for conveying the tops and shelves through a coating zone between two fine-wire electrodes while spray guns of conventional type employing compressed air for paint-atomization directed sprays of paint into the space between each electrode and the articles moving past it. [fol. 641] High voltage equipment supplied by said Ransburg Electro-Coating Corp. maintained an electrostatic field between the electrodes and the work, and the paint sprays entered such field at an acute angle to the path followed by the articles.

On or about November, 1952, the aforesaid painting equipment was replaced by new equipment in which the work is conveyed past and in spaced relation to a number of atomizers maintained at an electrical potential of about 70,000 volts with respect to the work. Paint supplied at a controlled rate to such atomizers is electrostatically atomized therefrom in the form of a spray and electrostatically deposited on the work. No compressed air is used to atomize the paint or to carry it to the work. The atomizers are mounted in fixed position with respect to the path followed by the table tops and shelves, and the operation is substantially fully automatic. The atomizing devices and related equipment including the paint-supply means and the source of high voltage were supplied by said Ransburg Electro-Coating Corp.

The new equipment has resulted in a substantial saving of paint, the extent of the paint-saving depending to a degree on the color of the paint. The most commonly

used paint is red in color, and with that paint the number of tops and shelves covered per gallon of paint used is, with the new equipment, more than twice what it was with the electrostatic coating equipment previously used.

In addition to the paint saving represented by the increase in the number of tops and shelves coated per gallon of paint used, the following differences exist between painting as performed with the old electrostatic coating equipment and painting as performed with the electrostatic atomizing equipment presently in use:

[fol. 642] a. The new process results in a substantially improved distribution of paint, the distribution of paint obtained with the present equipment being substantially uniform.

b. The present equipment is able to deposit approximately twenty-five per cent more paint in a single pass of the articles through the coating zone, the conveyor speed being the same in both instances.

c. The former electrostatic process required two touch-up men operating manually directed spray guns to apply paint to areas insufficiently coated by the electrostatic coating equipment previously in use. With the present equipment, no touch-up men are needed.

d. The former electrostatic method required a water-washed spray booth and a relatively large-capacity air moving apparatus for entrapping oversprayed paint and ventilating the spray booth, whereas the present equipment requires only a low-capacity ventilating system for removing solvent-vapor and there is substantially no oversprayed paint to entrap.

e. With the former electrostatic coating equipment, an average of about eighteen man-hours were devoted nightly to the job of cleaning electrodes, the floor and walls of the booth, and the spray equipment and to removal of over-spray sediment in the

water-wash tanks. With the present equipment, nightly clean-up work has been reduced sixty-five to eighty per cent.

f. The present equipment, being dependent upon electric power alone, is less subject to interruption in operation than was the prior equipment, which was dependent upon electric power, compressed air, and water supply.

[fol. 643] g. The old electrostatic coating equipment required more frequent adjustment than does the present equipment to maintain adequate coverage and quality of finish.

GILBERT ISGRIGG.

Subscribed and sworn to before me this 10th day of March, 1953.

(SEAL) WALTER MILLER,
Notary Public.

My commission expires May 25, 1954.

AFFIDAVIT OF DONALD C. HOWARTH FILED MAR. 20, 1953.

State of Indiana
County of Marion } ss.:

Affidavit.

Donald C. Howarth, of Indianapolis, Indiana, being first duly sworn, deposes and says as follows:

I am, and for several years have been, employed by Ransburg Electro-Coating Corp. of Indianapolis, Indiana.

My employer owns patents and patent applications relating to methods and apparatus for electrostatic spray painting, licenses manufacturers to use such methods and apparatus, and provides many of its licensees with certain portions of the equipment employed in practicing the licensed methods.

For the last several years, my duties for my employer have involved supervision of the installation of licensed methods and apparatus and supervision of all billing to licensees.

Electrostatic spray painting methods licensed by my employer have been of two general types. In one type, [fol. 644] hereinafter referred to as the No. 1 method, articles to be painted are moved on a conveyor past a charged electrode, or between two spaced charged electrodes, while paint sprays formed by conventional spray guns employing compressed air have been discharged into the electrostatic field between the electrode or electrodes and the articles, such sprays being directed at an acute angle to the direction of article movement. In the other process, hereinafter referred to as the No. 2 process, articles to be coated are conveyed past and in spaced relation to one or more atomizers normally maintained at an electrical potential of about 70,000 volts with respect to the work, while paint supplied at a controlled rate to such atomizers is atomized and electrostatically deposited on the work without employment of any compressed air.

The aforesaid No. 1 method was in use, and was the subject of hundreds of licenses to manufacturers, for several years prior to the introduction of the No. 2 method. Although a few licenses to practice the No. 2 method had been granted prior to the third quarter of 1951, it was not until that time that Ransburg Electro-Coating Corp. published information as to that method or embarked on any intensive effort to exploit it commercially. Up to the present time, there are seventy-eight (78) manufacturers licensed to employ one hundred one (101) No. 2 units, and additional licenses to employ that method are being granted as rapidly as the Ransburg organization can handle engineering and supervision necessary to new installations.

Some of the companies which now employ the No. 2 process under license from my employer are:

Aluminum Goods Manufacturing Company
Arvin Industries, Inc.
E. I. DuPont de Nemours & Company

General Electric Company
Houdaille-Hershey Corporation
[fol. 645] Johns-Manville Corporation
Landers, Frary & Clark
Monroe Auto Equipment Company
Proctor Electric Company
Reo Motors, Inc.
Reynolds Metals Company
Speed Queen Corporation
The Studebaker Corporation
Taylor Wharton Iron & Steel Company
Thor Corporation
Whirlpool Corporation

Of the seventy-eight (78) companies licensed by my employer to use the No. 2 process, a substantial portion of them are employing it to replace the No. 1 process which my employer had previously licensed them to use.

Licenses to use the No. 2 process granted by my employer require the payment of an initial fee, varying from $5,000 to $40,000, depending upon the size and nature of the installation and the amount of equipment they ask my employer to supply, and also require the payment of subsequent monthly fees depending in amount upon the quantity of paint used.

As a result of my work, I believe I am familiar with all types of spray coating processes generally used in American industry. The aforesaid No. 2 process is the only spray coating process known to me which, in an industrial spray painting operation, can use substantially all the coating material sprayed.

DONALD C. HOWARTH.

Subscribed and sworn to before me this 12th day of March, 1953.

IRIS M. MCKENNA,
Notary Public.

My Commission expires Oct. 6, 1954

[fol. 646]

PAGE 15 OF APPLICANT'S BOARD OF APPEALS BRIEF
FILED MAY 25, 1953.

The Helmuth affidavit testifies to a paint loss of 40%-55% in the painting of refrigerator panels and cabinets with air-atomized paint, non-electrostatically deposited. The Juvinall affidavit states that in applicants' process work of the same type received 99% of the paint used, and that even on such "open" articles as automobile steering wheels 97% of the paint was deposited on the articles. Helmuth refers to the skilled labor and overspray-collecting equipment necessary in painting refrigerator cabinets by the conventional spray-gun technique.

Gilbert Isgrigg has had experience in painting metal-table tops and shelves by applicants' method and by a method employing electrostatic deposition of air-atomized paint. His affidavit establishes that applicants' method and apparatus doubles paint-utilization efficiency, provides a heavier and more uniform coating, removes the necessity for "touch-up" men, makes possible the elimination of paint-recovery equipment, is subject to less frequent interruption of operation, reduces maintenance labor, and requires less frequent adjustment.

The affidavit of Donald C. Howarth testifies to the wide acceptance and commercial success of applicants' invention on industrial production lines. At the date of the affidavit, 78 licensees including such companies as General Electric, Dupont, and Studebaker had paid substantial initial sums and were making continuing monthly payments for the right to use 101 production units embodying the invention.

The advantages and commercial success to which the affidavits testify establish that applicants' invention possesses real worth and constitute compelling evidence that what applicants have done would have been done much earlier had it required only mechanical skill.

[fol. 647] VI. The Prior Art.

The principal reference relied upon by the Examiner is the Formhals patent No. 2,187,306, which shows a process of making a composite thread by collecting fine fibres on a base thread and then rolling such fibres into contact with the base thread.

Page 5 of Board of Appeals Decision of December 18, 1953.

Appeal No. 372-08

The other patents relied on by the Examiner, Althouse and Gundelfinger, show that the use of belts for conveying thread is well known in the art. These patents require no detailed description.

The Examiner has taken claim 88 as illustrative of the method claims under consideration. He contends that the only distinguishing feature of this claim over Formhals lies in the statement that the liquid is dispersed and deposited while still in a liquid state, and he holds that "such a statement adds nothing patentable to the process of Formhals but merely states what are the results desired." With reference to claims 72, 89, 91, 96, 97, and 99, the Examiner points out that these claims omit the limitation contained in claim 88 to the effect that the particles as deposited are liquid.

In controverting the rejection of the claims, the appellants contend that they were the first: "to spray paint onto an article surface by electrostatically atomizing it into discrete particles, electrostatically dispersing those particles, and electrostatically depositing them while still liquid," thereby eliminating the necessity for atomizing air and attaining high paint-utilization efficiencies and other advantages testified to in the affidavits filed in the present case.

[fol. 648] We have examined these affidavits with care and we find that they establish beyond question that the spray-painting process to which the claims are directed has achieved commercial success.

The appellants further argue that:

"it is improper to regard Formhals' stream-shattering as 'atomization' or his long fibres as 'particles'; but even if that point be waived, Formhals' fibres are not discrete or dispersed, because they are continuous with the mother stream and connected with each other by virtue of that continuity."

[fol. 649]

Defendant's Exhibit 6

IN UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF INDIANA

INDIANAPOLIS DIVISION

Amendment C filed August 23, 1956

IN THE UNITED STATES PATENT OFFICE.

In re application of William A. Starkey *et al.* Serial No. 434,366 Filed June 4, 1954	Apparatus for Electrostatically Coating Articles. Division 25.

AMENDMENT "C".

Hon. Commissioner of Patents,
Washington, D.C.

Sir:

Please enter the following amendment:

In the specification:

Page 1, line 3, after "No." insert —2,685,536—; same line, after "granted" insert —August 3, 1954—.

Page 6, line 16, after "material." add — As illustrated in the drawings, the needles are sufficiently close together as to cause the coating material to bridge the spaces therebetween.

In the claims:

Cancel claims 1, 9, 12, 13, 15, 16, and 17 without prejudice.

Please insert the following new claim:

(4.) ~~9~~. ~~18~~. Apparatus for electrostatically spray-coating an article, comprising an atomizing head, means [fol. 650] for feeding liquid coating material to said head, means including said feeding means for distributing coating material to an extended atomizing zone where it is atomized from a plurality of spaced points, said points being sufficiently close together to permit the coating material to bridge the spaces therebetween, a support for

supporting an article to be coated in spaced relation to said atomizing zone, a means including a high-voltage

source for creating over the surface of the article on said support an electrostatic field capable of atomizing the coating material into finely divided, electrically charged particles and electrostatically depositing particles

atomized from said atomizing zone on the article while still

in liquid state, said atomizing head and support being so

relatively disposed as to provide between the article and

the atomizing zone a spacing great enough to permit substantial dispersion of the atomized particles by the electrostatic forces of the field.—

REMARKS.

Applicants' attorney desires to express his appreciation for the courtesies extended to him at the recent interview with the Examiner in charge of the application.

At the interview, the final rejection of the claims on the grounds stated in paper No. 9 were discussed at some length and a new claim (here submitted as claim 18) was also discussed.

[fol. 651] It was pointed out that one of the features of the suggested new claim is the provision of feeding means which distribute coating material to an extended atomizing zone from which zone it is atomized from a plurality of spaced points with the points being so close together as to permit the coating material to bridge the spaces therebetween. Such, of course, is not the system of Formhals as, regardless of the spacing of his nozzles, the coating material being contained within the nozzle could not bridge the space therebetween.

It was suggested by the Examiner that the obviously inherent bridging of the coating material at least in the apparatus illustrated in Figures 5 and 6 be pointed out in the specification and accordingly the specification has been amended to do so.

The unallowed claims remaining in the application are proposed to be cancelled with this amendment and it was believed at the interview that an action of this nature by applicants would place the case in condition for allowance.

Therefore, withdrawal of the final rejection, entry of the present amendment, and reconsideration and allowance of the application as now presented are respectfully requested.

Respectfully submitted,

SCHROEDER, HOFGREN, BRADY & WEGNER,
WILLIAM J. STEELMAN.

Chicago, Illinois,
August 21, 1956.

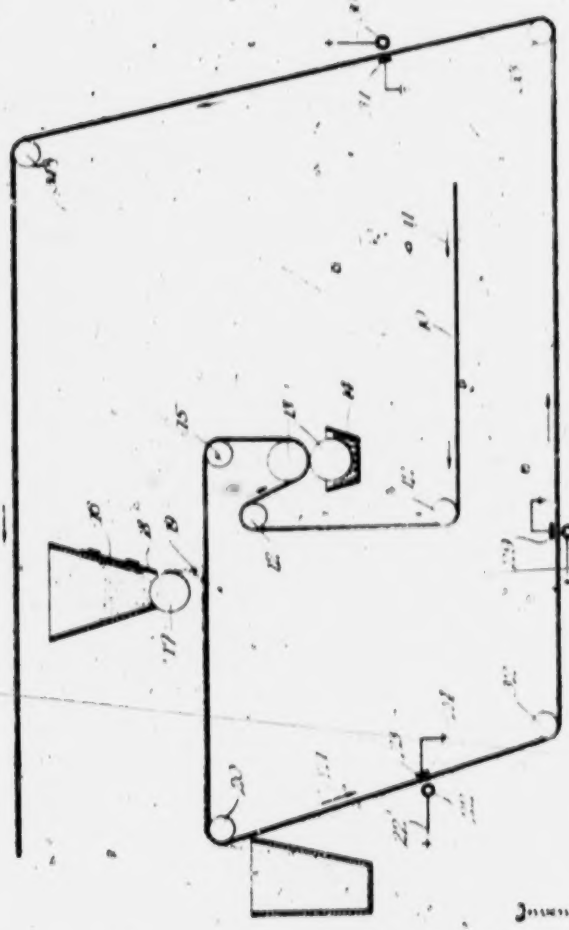
[fol. 652]

Defendant's Exhibit 21

April 12, 1932. E C SCHACHT 1,854,071

METHOD OF MAKING ABRASIVES

Filed July 14, 1930



Inventor
Elmer C. Schacht,
By Carlton Bryant & Darby
Attorneys

[fol. 653]

Patented Apr. 12, 1932

1,854,0

UNITED STATES PATENT OFFICE

ELMER C. SCHACHT, OF TROY, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO BERR-MANNING CORPORATION, A CORPORATION OF MASSACHUSETTS

METHOD OF MANUFACTURING ABRASIVES

Application filed July 14, 1930. Serial No. 467,981.

The present invention relates to abrasives, and more particularly to an improved method of manufacturing abrasives, such as sand paper.

The invention has as an object a novel method for controlling the disposition of the abrasive particles on their carrier and thereby producing a sharper and more efficient abrasive surface.

The invention seeks to provide a method for positioning or orienting the individual abrasive particles which form the abrasive surface so that the sharpest portion of substantially each particle will be exposed.

The method will be described in connection with the manufacture of an abrasive material, such as sand paper, although it will be understood that the invention is applicable to any type of abrasive material.

Abrasive paper, by which is meant any abrasive sheet or strip material having a surface of abrasive material, such as sand, ordinarily consists of a backing or carrier of paper or fabric, or combined paper or fabric, upon which the abrasive particles are retained by an adhesive. Usually the adhesive is applied to one surface of the carrier and thereafter the abrasive or cutting material is deposited on the adhesive surface where it is retained by the latter. The commonly employed particles are of irregular formation and ordinarily have one axis of greater dimension than the other, as well as surfaces which are sharper than other surfaces and, therefore, more suited for abradent action. It is desirable that these sharper surfaces be exposed to provide a relatively more efficient abrasive material. Moreover, the broader surfaces afford a more effective area for adhesively anchoring the individual particles to the carrier.

The present invention provides a novel method for producing this result and for arranging the particles so that their sharper portions are exposed and their broader surfaces adhesively joined to the carrier.

The invention involves the use of an electrical charge, produced by an electrical field which is preferably of electrostatic character, arranged to influence the individual particles so that each particle has exposed sharpest and most effective portion.

In carrying out the method, a supply sand may be arranged in a hopper above adhesively surfaced carrier or backing. hopper may be provided with the usual and feed roll for controlling to a certain tent the showering of the sand upon the hesive surface to be coated, although the may be deposited upon the carrier in ex of the quantity desired. After the sand been deposited upon the carrier, and any cess particles which are not required forming the abrasive surface have been moved, the carrier is subjected to the act of an electrical field, preferably of elect static character. The electrical field is ployed while the adhesive is not fully and preferably before it is hardened to appreciable extent. If the adhesive has ha ened more than is desired it may be soften by the application of heat or by other me so that the action of the electrical field m produce the desired effect.

The electrical field is arranged so that positions of the individual particles changed to expose the sharpest portion each particle. The electrical field is utili by passing the abrasive surface therethrou and it has been found that there is obtained this manner the proper orientation of e individual particle so that its sharpest porti is exposed.

It is believed that the field causes e particle substantially to align itself so th its longitudinal axis is virtually parallel the lines of force of the field. The rate discharge of an electrostatic charge is dependent upon the surface characteristics the charged body and the longer the radi of curvature the slower the rate of discharg the sharper the point, the faster the rate discharge.

It is believed that this relation of the r of discharge and the surface characteristi of the charged body, e. g. sand grain with pointed abrasive portion, causes the sharpe points in the grains to be arranged so as discharge in the direction of the field. If t field is at one side of the carrier, it follo

[fol. 654]

that any particles which are embedded in the adhesive in such a way that the sharpest points are not exposed will be turned or repositioned to cause the sharpest points to be directed to the electrostatic field and away from the carrier surface. Consequently, the many particles which do not have their points exposed when deposited upon the carrier will be oriented or changed in position by the action of the electrical field which exerts, in effect, a leverage upon the particles.

The location of the field in practicing the method will be dependent upon the "setting" of the adhesive. Rapid drying adhesive, such as lacquer, sets almost instantly and the field should be very close to the point where the sand is applied. Glue, on the other hand, requires a longer time to set, and varnish a still longer period. Therefore, the position of the electrical field may be altered according to the type of adhesive employed.

Moreover, the character or power of the field may be modified by modifying the position and size of the electrode, or changing the voltage. This phase of the invention need not be described in detail, since it is disclosed in my copending application Serial No. 296,323, filed July 30, 1928 which relates to a somewhat different process, but covers the broad idea of utilizing an electrical field for orienting the abrasive particles.

For practicing the method, various forms of apparatus may be employed.

In the accompanying drawing there is shown somewhat diagrammatically a suitable apparatus.

10 indicates the carrier or paper sheet which may be fed in the direction of the arrows 11 by suitable means (not shown) over guide rolls 12 and between coating rolls 13 which deposit a suitable adhesive from an adhesive container 14 upon one surface of the carrier. The coated surface, after passing over a roll 15, travels beneath a sand hopper 16 having a feed roll 17 and an adjustable controlling gate 18 for regulating the supply of abrasive material such as sand particles 19 to the exposed surface.

As illustrated in the drawing, the sand may be supplied in excess of the quantity required and at a roll 20 the carrier may take a sharp turn to provide a vertical run, indicated by the arrow 21, for the purpose of causing removal by gravity of the excess sand which has not been adhesively retained upon the surface. As will be understood, it is not necessary that this excess abrasive be applied and to control accurately the application of the abrasive, the gate and feed roll of the hopper 16 may be adjusted and other controlling means such as an electrical field of the character disclosed in my copending application may be utilized adjacent the hopper.

After the excess abrasive, if any, has been removed, the abrasive surface may be subjected to an electrical field. This field changes the positions of the individual particles, particularly of those particles which do not have their sharpest portions exposed.

The change of position of the various particles occurs in several ways: First, the particles which do not have their sharpest portions exposed are oriented or turned by the lines of force so that the sharper surfaces of the abrasive coating are exposed. Secondly, the various particles upon the surface are stratified, with the result that the larger or more effective particles are carried to the surface. As will be understood, in the manufacture of sand paper of any particular grade, the particles vary in size and will include both under-grade and over-grade sizes. The electrostatic field tends to carry to the top surface the larger particles, that is, the particles having the larger areas of cutting surface. Consequently, the change of position results from both orientation, i. e., turning of the particles so that their longest axes are parallel to the lines of force and to stratification, which results in the carrying of the larger particles to the surface of the carrier. The electrical field, which is preferably of electrostatic character, may be formed by a discharge electrode 22 connected by a lead 22' to a source of high voltage (not shown). This electrode is disposed at the abrasive side of the carrier and cooperates with an electrode 23 grounded at 24 and disposed on the opposite side of the carrier for the purpose of forming a zero or ground potential side of the field. The field may be varied in intensity and extent as desired and it may be found desirable to vary these characteristics in accordance with the extent to which the particular adhesive employed has set and in accordance with different sizes or kinds of abrasive particles. It is possible, for example, to make a field of higher unit intensity by reducing the diameter of the tube 22, or a broader field, or one of lower unit intensity, by increasing the diameter of the tube. The proximity of the ground or zero electrode potential 22 affects the field.

As explained in my copending application, it has been found that by moving the tube 22, as by rotation, there will be produced a pronounced effect upon the character of the field.

At times it may be found desirable to subject the carrier repeatedly to the electrical field and for this purpose there may be provided a second electrical field produced by electrodes 28, 29 and a third field produced by electrodes 30 and 31 arranged in relation to the carrier in the same manner as the field first described. The carrier in passing through these fields for repeated subjection to electrical action traverses rolls 32, 33 and 34 and from the latter may be subjected to the usual finishing operations.

By the expression "adhesive action", and

"adhesively retaining" as used in the specification and claims with reference to the retention of the abrasive particles upon the carrier, is meant any means other than electrical for retaining the abrasive material on the carrier surface. By "abrasive" is meant any abrasive or coating material in fragmentary form; by "carrier" is meant any desired material or support on which the fragmentary or divided material may be imposed or deposited. Obviously, the method described in detail may be varied considerably without departing from the invention and apparatus considerably different from that illustrated and described may be employed for practicing the method, the essential characteristics of which are set forth in the following claims.

I claim:

1. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, applying finely divided abrasive material to said adhesive surface and after deposit of the abrasive, but while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by progressively subjecting the abrasively coated surface to the action of an electrical field.

2. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, applying finely divided abrasive material to said adhesive surface and after deposit of the abrasive, but while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by passing the abrasively coated carrier surface through an electrical field.

3. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, applying finely divided abrasive material to said adhesive surface and after deposit of the abrasive, but while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by repeatedly subjecting the abrasively coated surface while the adhesive ly to electrical action.

4. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, depositing finely divided abrasive material on said surface in excess of the amount required to form the desired abrasive coating, removing the excess abrasive after depositing the same and then, while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by progressively subjecting the abrasively coated surface to the action of an electrical field.

5. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, depositing finely divided abrasive material on said surfaces in excess of the amount required to form the desired abrasive coating, removing the excess abrasive after depositing the same and then, while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by passing the abrasively coated carrier through an electrical field.

6. In the manufacture of abrasives, the improved method which consists in providing a carrier having a surface of adhesive material adapted to retain abrasive material deposited thereon, depositing finely divided abrasive material on said surface in excess of the amount required to form the desired abrasive coating, removing the excess abrasive after depositing the same and then, while the adhesive is not fully set, changing the positions of the individual abrasive particles on said surface by repeatedly subjecting the abrasively coated carrier to electrical action.

7. In the manufacture of abrasives, the improved method of treating a carrier having a surface coated with abrasive particles, adhesively retained on said surface, which consists in changing the positions of the particles by subjecting the surface while the adhesive is not fully set to the action of an electrical field at a point remote from the point of application of the abrasive.

8. In the manufacture of abrasives, the improved method of treating a carrier having a surface coated with abrasive particles, adhesively retained on said surface, which consists in changing the positions of the particles by repeatedly subjecting progressively the abrasively coated surface while the adhesive is not fully set to electrical action.

9. In the manufacture of abrasives, the improved method of treating a carrier having a surface coated with abrasive particles, adhesively retained on said surface, which consists in changing the positions of the particles by progressivley passing the abrasively coated surface through an electrical field.

10. In the manufacture of abrasives, the improved method of treating a carrier having a surface coated with abrasive particles, adhesively retained on said surface, which consists in changing the positions of the particles by repeatedly passing the abrasively coated surface through an electrical field.

In testimony whereof I have hereunto set my hand.

ELMER C. SCHACHT.

[fol. 656]

4

CERTIFICATE OF CORRECTION.

Patent No. 1,854,071. Granted April 12, 1932, to

ELMER C. SCHACHT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:- Page 3, line 52, claim 3, before the word "surface" insert the word carrier, and lines 52 and 53, same claim, strike out the words "while the adhesively" and insert the word progressively; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of June, A. D. 1932.

H. J. Moore,
(Seal) Acting Commissioner of Patents.

[fol. 657]

July 14, 1936. A. THODE 2,047,525

INSULATING METHOD FOR ELECTRIC AND THERMO-TECHNICAL PURPOSES, AND APPARATUS FOR ACCOMPLISHING THE SAME

Filed Sept. 19, 1932

Fig 1

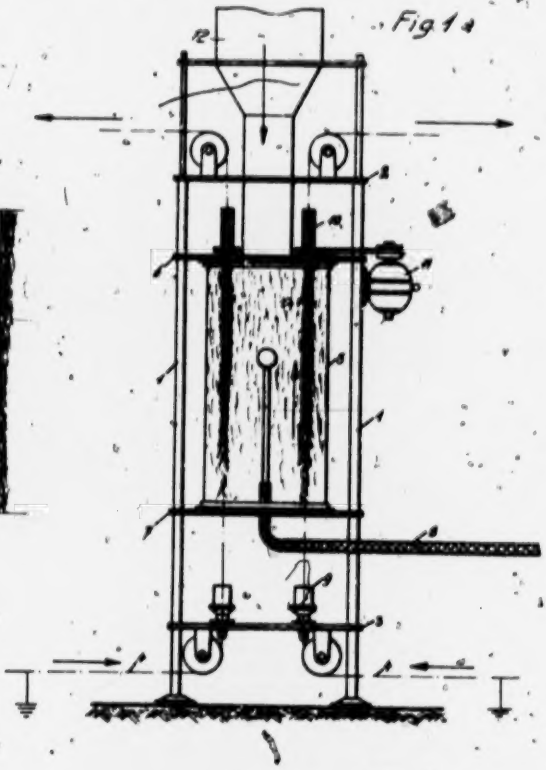
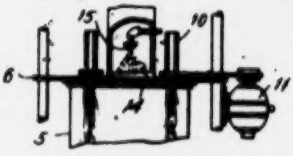


Fig 3

Fig 2

Fig 4



Inventor:

Adolf Thode

[fol. 658]

Patented July 14, 1936 2,047,525

UNITED STATES PATENT OFFICE

2,047,525

INSULATING METHOD FOR ELECTRIC AND THERMO-TECHNICAL PURPOSES, AND APPARATUS FOR ACCOMPLISHING THE SAME

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24 Claims. (Cl. 91—13)

(Granted under the provisions of sec. 14, act of March 2, 1927; 357 O. G. 3)

For the insulation of electric conductors the whipping method has been hitherto applied, according to which the conductors are whipped with yarns, produced from textile materials, such as cotton, silk, asbestos and others. This method is very complicated and requires time, as from the textile material has first to be produced thread, or, if paper is to be used for insulation, a paper strip has first to be produced from the raw paper material.

To overcome this inconvenience, it has been proposed to use flaky, fibrous material which, with the aid of special devices, is applied on to the conductors as a di-electric or insulative coating. According to a proposed method the flaky material is moved in a continuous, uniform eddy by a circulating air current. The air current conveys the flaky material to cylinders which supply it to the wire to be insulated and which has been previously coated with gum. Owing to the gum, the flocks stick on the wire, distributed as uniformly as possible over the entire length and circumference of the same. The difficulty connected with this insulating method is that the flocks cannot be brought on to the conductors so uniformly that the diameter of the insulation is the same at all points of the wire surface. The speed at which the blowing on of the sticky conductor by an air current saturated with textile fibres takes place can be only limited as, if the speed of the gas or air is increased, the fibres which have already stuck on the wire might be torn away. This happens especially with fibres designed not to stick directly on the conductor but on fibres already covering the conductor, for instance if the thickness of the insulation has to be increased. The method according to the present invention avoids all the inconveniences of the commonly applied methods. It is based on the fact that bodies with similar electric charge (+ or −) repel one another, whereas bodies with opposite charge attract one another. The method is characterized chiefly by the use of high-voltage electric currents for opening and distributing insulating material of any kind.

These currents are further used for applying the insulating material on to the electric conductors. The individual fibres and particles of the material are electrically charged through the pole of a high voltage source so that they deposit on bodies, which are connected to the opposite pole of the high voltage source. The arrangement may be made so that the bodies to be insulated are grounded and that the other pole of the high voltage source is grounded also.

The insulating of the conductor according to this method is carried out much more rapidly (about 25 times as rapid) than the hitherto employed method, and it permits of the simultaneous insulating any desired number of conductors in one operation, which may all be of the same diameter or of different diameters. The insulating layer obtained in this manner is of uniform thickness on all points of the conductors, and it is possible to regulate the thickness of the insulating layer as desired, as the method is carried out in an undisturbed atmosphere, as will be hereinafter explained.

An apparatus employed for carrying out the new method is diagrammatically illustrated by way of example in the accompanying drawing, in which:—

Fig. 1 is a side elevation and

Fig. 2 a top plan view.

Fig. 3 shows a section of a conductor covered, fox-tail like, with insulating material, the covering being not yet smoothed.

Fig. 4 shows a fragmental vertical section of an upper portion of a modified form of the apparatus.

The apparatus consists of uprights 1 connected at the top end and near the lower end by transverse bars or plates 2 and 3, on which pulleys for changing the direction of the conductors 4 are mounted. The uprights 1 carry a cylindrical container 5, made of transparent, insulating material, preferably glass. This container 5 is closed at the top and bottom by cover plates 6 and 7. A sputtering electrode 8 projects from below into the container 5 and represents one pole of the high voltage source. The conductors 4 to be insulated pass through the container 5, and any number of conductors are grouped around the sputtering electrode 8 at a suitable distance from the same. On the lower transverse plate 3 containers 9, filled with adhesive are mounted, through which the conductors to be insulated are passed prior to passing through the container 5. Insulation smoothing devices 10 are mounted on the cover plate 6, one for each conductor 4, these being designed to smooth the insulating material adhering to the conductor as the conductor passes through the center bore thereof. The smoothing devices are rotatively driven from a motor 11. The loose fibrous material is fed to the container 5 through a charging funnel 12 mounted on the cover plate 6.

The method is carried out in that the covering material, for instance textile fibres or paper dust, loosened, for instance, by rapidly rotating brushes, flows through the funnel 12 into the transparent container 8. The insulating material in the container is electrically charged by the influence effect of sputtering electrode 9 connected to the high voltage source. This charging with electrons of similar polarity effects a further loosening of the insulating material as the individual particles repel one another, according to the law that bodies of similar electric charge repel one another. The electrically charged particles possess the tendency to move away from the sputtering electrode, the point of high potential, in outward direction towards the zone of low potential (phenomenon of the electric wind). This tendency is especially favorable for this method. The particles are thereby thrown against the adhesively coated conductors 4 to be insulated which are conducted through the container at a suitable distance from the sputtering electrode 9. These conductors, being grounded, or connected to the other pole of the high voltage source, attract with high velocity the ionized particles of insulating material. These particles, shot against the bare conductors, cover the same in foxtail-like formation. The foxtail-like coverings are then smoothed as they are drawn through the smoothers 10. The conductors are then perfectly insulated.

The conductors 4, before they enter into the container 8, are passed through the containers 9, so that they are coated with a suitable adhesive, whereby the adhesion of the particles of insulating material to the conductor is facilitated.

The coating of the conductors with adhesive may however be effected in that the adhesive is introduced in the form of mist 16 (Fig. 4) from a nozzle 18 into the container 8. The mist particles are then submitted to the same law as the fibre particles, that is, they are electrically charged and fly on to the conductors to be insulated. As the adhesive mist is also distributed between the particles of insulating material, the cover on the conductors consists of a mixture of adhesive and fibre particles. It is not absolutely necessary to coat the conductors with adhesive, as the particles of insulating material adhere well to the conductors when the current has been cut off, as, owing to the high speed at which they flow towards the conductors, they intermix and become matted so that they form a dense cover. The thickness of the insulating layer can be regulated very accurately and in a simple manner by varying the strength of the electrical potential, as with increasing potential also the force which separates the particles of the insulating material increases, and also the speed with which the particles flow towards the conductors. If the electrical potential decreases, the reverse condition occurs. A further possibility of regulation consists in altering the speed with which the conductors pass through the container 8 filled with electrically loaded fibres and along the sputtering electrode 9. At higher speed the layer of insulating material becomes thinner and it becomes thicker at lower speed. Another possibility of regulation is to regulate or alter the quantity of fibres fed into the container in a unit of time. Conductors of different thickness can be insulated at the same time, if for every conductor a drive is provided which can be regulated, as the speed with which the conductors are moved through the container 8 is different according to the thickness of the conductor and of the insulation to be produced. In order to attain a uniform distribution of the insulation over the entire circumference of conductors, that is also on the side of the same turned away from the sputtering electrode 9, driving gears of known type, not shown on the drawing, are provided, which effect the speed of rotation of the conductors. An advantage of the method not to be underestimated is, that the insulating material is completely used up, as the particles are whirled up continually as long as they remain ionised and as they give up their charge only when they come in contact with the conductor. Another chief advantage of the method is that the covering of the conductors with fibrous material is carried out in the closed container 8, in an undisturbed atmosphere.

The insulating speed can be increased as desired by increasing of the voltage.

According to this method not only wires or stranda, but also shaped elements of any form can be insulated.

High voltage direct current as well as alternating current can be used.

I claim:—

1. A method of electrically depositing particles of insulating material on an electrical conductor; consisting in disposing the conductor in the particles, charging the conductor at a certain potential, charging the particles at a different potential, and moving the charged particles to the conductor.

2. A method of coating an electrical conductor with particles of insulating material; consisting in disposing the conductor in the particles, applying a thin liquid, settable adhesive coat to the conductor, charging said conductor electrically at a certain potential, charging the particles at a different potential, and moving the charged particles on to the settable coat, so that the latter may dry to hold the particles in position.

3. A method of applying a coat of insulating particles to an electrical conductor; consisting in disposing the conductor in a mass of particles of insulating material and wet adhesive material, charging the conductor electrically at a low potential, charging the particles at a high potential, moving some of the insulating and adhesive charged particles into attached relation on the conductor, and removing the latter from the mass.

4. A method of applying a coat of insulating particles to an electrical conductor; consisting in disposing the conductor in a mass of the particles of insulating material and liquid adhesive material charging the conductor electrically at a low potential, charging the particles at a high potential, whereby sufficient of said particles may be attracted to the conductor to form a relatively large coat thereon, removing the coated conductor from the mass, so that the adhesive material may dry, and smoothing the attracted particles on the conductor as it leaves the mass whereby to provide a smooth surface on the coat.

5. A method of applying insulating particles to the surface of an electrical conductor; consisting in, rendering the surface adhesive, disposing the conductor in a mass of the particles, charging the conductor electrically at a certain potential, charging the particles at a different potential whereby some of the particles may fly to the conductor and form a coat on said surface, removing the conductor from the mass, and smoothing the surface of the coat.

[fol. 660]

6. An apparatus for coating movable electrical conductors comprising in combination a container of insulating material, the conductors being movable through the container in an annular series; means for delivering particles of fibrous coating material into the container around the conductors; said container having therein a central electrode which is adapted to deliver therefrom a high potential charge; means for delivering a thin adhesive covering to the conductors as they move into the container, said conductors adapted to be charged electrically at a low potential; so that as the charge is delivered from said electrode the particles may also be charged, whereby said particles may be attracted to the conductors to coat the latter, and means for smoothing the coated conductors as they leave the container.

7. An apparatus comprising means for charging, with high potential, small particles of insulating material; and means for charging an adhesive-coated wire conductor, near said particles, with lower potential.

8. An apparatus comprising means for providing a closed insulated space; means for supporting a conductor in said space; means for feeding, into said space, separated small particles of insulating material and a plurality of adhesive particles; means establishing a charge of high potential in the space; and means for charging said conductors with a lower potential.

9. An apparatus comprising means providing a laterally closed insulated space; means for holding a conductor in said space; means for simultaneously feeding into space a plurality of separated small particles of insulating material and adhesive particles separated in the form of a mist; means for establishing a charge of high potential in said space; means for charging said conductor with potential opposite in sign to that of said charge.

10. An apparatus comprising means for providing a laterally closed and insulated space; means for continually feeding a plurality of spaced conductors upwardly through said space; means for applying a settable adhesive to and around each conductor before it enters said space, means for feeding into said space a plurality of small particles of insulating material; means for establishing a charge of high potential in the midst of said space, whereby said particles are charged with charges of like sign, and are therefore further separated from each other and driven from said charge; means for charging said conductors with potential lower than that of said charge; whereby the particles are drawn at high speed strongly to said conductor and adhesive and permanently adhered to the adhesive and to each other, thereby distributing the particles around the conductors within a fox-tail-like formation; and means smoothing said formation around the conductor as latter passes from said space, thereby forming an effective insulating coating.

11. An apparatus comprising means for providing a laterally closed and insulated space; means for continually feeding a plurality of spaced wire conductors upwardly through said space; means for feeding into the top of said space a plurality of separated small particles of insulating material; means for introducing into said space, simultaneously with the particles, a plurality of adhesive particles separated in the form of a mist; means for establishing a charge of high potential in the midst of said space substantially equidistant from said conductors, whereby said particles are charged with charges of like sign, and are therefore further separated from each other and driven from said charge; means for charging said conductors with potential opposite in sign to that of said charge, whereby the particles are drawn at high speed strongly to said conductor and adhesive and are permanently and evenly adhered to the adhesive and to each other, thereby distributing the particles evenly around the conductors within a fox-tail-like formation; and means for smoothing said formation tangentially around each conductor as latter passes from said space, thereby forming an effective insulating coating.

12. A method comprising charging, with high potential, small particles of insulating material; and charging an adhesive-coated wire conductor near said particles with a lower potential.

13. A method comprising charging with high potential separated small particles of insulating and adhesive material; and charging a wire conductor, near said particles, with a lower potential.

14. A method comprising, providing a closed insulated space; supporting a conductor in said space; feeding, into said space, separated small particles of insulating material and a plurality of adhesive particles; establishing a charge of high potential in the space; and charging said conductors with a lower potential, thereby adhering the particles around the conductor without the necessity of first coating the conductor.

15. A method comprising continually feeding a plurality of spaced conductors of different diameters upwardly through a laterally insulated and closed space of quiet air; charging insulating particles in said space with high potential and the conductors with lower potential.

16. A method comprising; providing a laterally closed and insulated space; continually feeding a plurality of spaced wire conductors upwardly through said space; feeding into the top of said space a plurality of separated small particles of insulating material; introducing into said space, simultaneously with the particles, a plurality of adhesive particles separated in the form of a mist; establishing a charge of high potential in the midst of said space substantially equidistant from said conductors, whereby said particles are charged with charges of like sign, and are therefore further separated from each other and driven from said charge; charging said conductors with potential opposite in sign to that of said charge, whereby the particles are drawn at high speed strongly to said conductor and adhesive and are permanently and evenly adhered to the adhesive and to each other, thereby distributing the particles evenly around the conductors within a fox-tail-like formation; and smoothing said formation tangentially around each conductor as latter passes from said space, thereby forming an effective insulating coating.

17. A method comprising continually feeding a plurality of conductors upwardly through a laterally insulated and closed space of quiet air; applying a settable adhesive to the conductors before they leave said space; loosening, separating and feeding into the top of said space a plurality of small particles of fibrous insulating material, whereby said particles will sink into the space; establishing a charge of high potential in the midst of said space substantially equidistant from said conductors, whereby said particles are charged with charges of like sign and therefore further separate from each other and

driven by the charge from said charge; simultaneously, with the establishment of said charge, charging said conductors with a potential opposite in sign to that of said charge; whereby the particles are drawn at high speed strongly to said conductors entirely by the force of the charges and adhere to the adhesive.

18. A method as in claim 17 including the step of applying the suitable adhesive to and uniformly all around the conductor before it enters said space.

19. A method as in claim 17 including the step of smoothing said formation tangentially around the conductor as latter passes from said space, thereby forming an adhesive insulating coating.

20. A method as in claim 17 including the steps of regulating the thickness of said formation by regulating the voltage of the charge, the speed of feed of the conductors, and the rate of supply of the insulating particles; and continuing said method until all of the fed particles are adhered.

21. In the art of covering wire conductors with insulation, a method which comprises supporting a wire conductor; simultaneously applying adhesive and small particles of fibrous insulating material around the conductor; and matting and adhering together the fibrous particles around the conductor as they are applied.

22. In the art of covering wire conductors with insulation, a method which comprises supporting a wire conductor; simultaneously applying adhesive and a plurality of separated small particles of insulating material around the conductor; adhering together the particles around the conductor in a fastail like formation without first coating the conductor; and smoothing said material, thereby compacting said formation.

23. In the art of covering wire conductors with insulation, a method which comprises supporting a wire conductor; simultaneously feeding into space near said conductor, separated small particles of fibrous insulating material and a plurality of adhesive particles; establishing a charge of high potential in the space; and charging said conductors with a lower potential; thereby causing matting and adhering together the fibrous particles around the conductor without the necessity of coating the conductor.

24. In the art of covering wire conductors with insulation, a method which comprises providing a closed space; supporting a wire conductor in said space, feeding into said space, separated small particles of insulating material and a plurality of adhesive particles; establishing a charge of high potential in the space; and charging said conductors with a lower potential; thereby causing the adhering of the fibrous particles around the conductor in a fastail like formation; and smoothing said material, thereby compacting said formation.

ADOLF THEXE.

[fol. 662]

July 20, 1937. L. P. MILLER 2,087,2[illegible]0

HOMOGENEOUS FILED SURFACE

Filed April 18, 1935

Fig. 1.

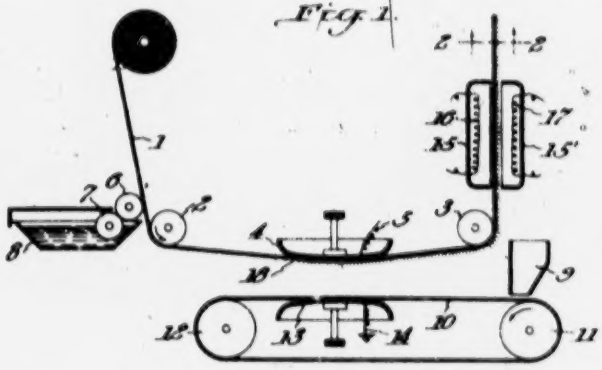

Fig. 2.

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[fol. 663]

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2,087,260

UNITED STATES PATENT OFFICE

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HOMOGENEOUS PILED SURFACE

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Application April 13, 1935, Serial No. 17,136

13 Claims. (Cl. 91—68)

This invention relates to piles and piled surfaces and their manufacture, and is directed particularly to a pile comprising attenuated elements and an indurated binding substance with which they are combined into a homogeneous structure, and to a method of making the same.

The invention is especially valuable when it is included in the method of piling surfaces comprising: coating the surface to be piled with adhesive, placing the coated surface in an electric field, and supplying fibers or other pile forming elements to the region of the electric field, that they may be oriented and deposited on the adhesive covered surface by the action of the electric field.

The principal object of the invention is to form a pile of attenuated particles, such as rayon fibers or "flocks", wherein one end of each fiber is incorporated into an indurated material and makes a homogeneous structure with it.

Another object of the invention is to incorporate one end of each of a group of fibers into an indurable binding material to form a pile by the use of a solvent common to fibers and binding material.

Another object of the invention is to so control the softening action of a solvent included in an indurable binding material on the fibers to be attached thereto in the forming of a pile that one end of each fiber will be amalgamated with the binding material to make a common substance with it.

A specific object of the invention is to make a pile of cellulose derivative fibers by fastening one end of each fiber into the pile structure with an adhesive, including a volatile solvent for the cellulose derivative, such as acetone, and then driving out the solvent and indurating the adhesive.

A further specific object is the production of a pile of attenuated elements upon a surface by coating the surface with an adhesive including a solvent for the elements, orienting the elements and projecting them endwise with an electric field into the adhesive, holding them in oriented position until the solvent has softened the imbedded ends of the elements and incorporated them into the adhesive to make a homogeneous structure with it, and then indurating the adhesive.

The products obtained from a realization of the above objects and such other objects as will be pointed out in the following exposition are characterized by the strong attachment between the individual fibers or elements and the common binding material. When very fine fibers, such as rayon flocks, are projected endwise, for instance under the influence of an electric field, into an adhesive, they do not penetrate deeply, as a rule, and are not always wetted sufficiently by an ordinary adhesive to produce a strong bond between adhesive and fiber. The result is a pile with an appreciable number of elements which will become dislodged when the pile is brushed or given other rigorous handling. An adhesive with a constituent that is a solvent for the fibers, on the other hand, definitely wets, and partially dissolves, each fiber that contacts it for any length of time, and the result is a blending or incorporating of fibers and adhesive into a homogeneous whole. Upon evaporation of the solvent or solvents and induration of the adhesive a very strongly bonded pile results.

In the following description of the invention reference is had to the appended drawing in which:

Fig. 1 is a diagrammatic view, in side elevation, of apparatus useful in practicing the method of the invention; and

Fig. 2 is a fragmentary cross-sectional view of the product made with the apparatus shown in Fig. 1 taken on line 2—2 of that figure.

In Fig. 1, numeral 1 identifies a sheet material, for example a sheet of closely woven cloth, a surface of which is to be piled. Sheet 1 is moved over rolls 2 and 3 in the direction indicated and in doing so passes under electrode 4 which is insulated from ground and maintained at a high potential with respect to ground by connecting it to a source (not shown) of high voltage, preferably unidirectional, current by conductor 5. A suitable adhesive is applied to the under surface of sheet 1 by rolls 6 and 7 in the manner readily appreciated by those familiar with the coating art. The adhesive is held in container 8, which has a close fitting top, except for the projecting area of roll 6, to minimize the losses of solvent by evaporation.

The attenuated elements, such as textile fibers, used in building the pile are distributed by means 9 upon belt 10 moving over rolls 11 and 12. Belt 10 may be of metal and held at ground potential, or it may be of semi-conducting or insulative material, in which case it is passed over an electrode 13, grounded at 14. In either case a strong electric field that terminates on electrode 4 exists adjacent the top of belt 10; and this electric field, which can be considered as existing between electrodes 4 and 13, lifts the fibers from the surface of belt 10 and di-

[fol. 664]

posits them on the coated surface of sheet 1 in oriented position perpendicular to that surface. Sheet 1 moves at a rate which permits the pile to form with the desired density. After deposition the piled surface is moved through a heating chamber 15, 15' containing electrical heating elements 16 and 7 wherein the solvents are driven from the adhesive, to be collected for reuse if economically advisable, and the adhesive hardened to the desired degree.

The several steps recommended in electrically depositing fibers are disclosed in detail in U. S. patent applications Serial No. 692,301, of A. F. Meston filed October 4, 1933, and Serial No. 699,456, of H. F. Wintermute filed Nov. 23, 1933.

Fig. 2 shows a portion of the product of the invention in which fabric 21 corresponds to sheet 1 of Fig. 1. A layer of binding material 22 is attached to the surface of cloth 21, and imbedded in or joined with the binding material are fibers 23. Binding material 22 had been applied to cloth 21 as a viscous adhesive composition and throughout the layer of adhesive a substance had been distributed which had a solvent or softening effect upon fibers 23. The solvent softened or partially dissolved the ends of the fibers projecting into or contacting the adhesive and brought about an intimate association of the materials comprising fibers and adhesive as shown at 24, with the result that upon driving out the solvent and indurating the adhesive the fibers were autogenously welded to the binding material in what may be termed a homogeneous whole.

I have obtained very satisfactory results with a solvent common to both binding material and fibers. For example, in depositing cellulose acetate rayon fibers, I have used acetone in an adhesive composition comprising cellulose acetate, a relatively high boiling point solvent, such as ethylene glycol mono-methyl ether ("Cellosolve") and a plasticiser. Deposition with this combination under conditions which controlled the evaporation of the acetone and the surface penetrativeness of the adhesive have produced piles with very strongly attached fibers. The deposition apparatus is preferably enclosed in a chamber when a highly volatile solvent, such as acetone, is used and it has been found advisable to control the gaseous contents of the chamber as to temperature and other vapor pressure conditions and to guard against possible explosive mixtures. The preferred viscosity and surface setting characteristics of the adhesive are readily discernible through trial and observation.

Other cellulose derivatives, such as the esters and ethers of cellulose, as well as other fibrous substances capable of being dissolved or softened by an ingredient of the adhesive composition, may be used in place of cellulose acetate.

While the invention has been particularly described for the purpose of illustration in connection with the production of a product including a fabric backing, other backings, such as sheets of preformed indurated material, may be used, or the fibers may be deposited on a layer of adhesive on a temporary backing, being later removed from the temporary backing and used as such or applied to a permanent backing.

It will be appreciated by those familiar with the characteristics of adhesives and textile and other fibers that many embodiments of my invention are possible. What I wish to emphasize as the broad conception of the invention is the breaking down of the surface of the fiber where it contacts the binding material so that the definite interface which ordinarily separates two such substances is, to an appreciable degree, eliminated and the fiber becomes integrally united with the binding material.

I claim:

1. A method of making pile-surfaced material which comprises depositing attenuated fibers of a cellulosic derivative in a layer of an adhesive composition including a substance having a solvent action on said cellulosic derivative, and indurating the adhesive layer.

2. A method of making pile-surfaced material which comprises depositing attenuated fibers of a cellulose ester in a layer of an adhesive composition including a substance having a solvent action on said cellulose ester, and indurating the adhesive layer.

3. A method of making pile-surfaced material which comprises depositing attenuated fibers of cellulose acetate in a layer of an adhesive composition including a substance having a solvent action on said cellulose acetate, and indurating the adhesive layer.

4. A method of making pile-surfaced material which comprises depositing attenuated fibers of a cellulosic derivative in a layer of an adhesive composition including a similar cellulosic derivative and a substance having a solvent action on said cellulosic derivative, and indurating the adhesive layer.

5. A method of making pile-surfaced material which comprises depositing attenuated fibers of a cellulosic derivative in a layer of an adhesive composition including cellulose acetate and a substance having a solvent action on said cellulosic derivative, and indurating the adhesive layer.

6. A method of making pile-surfaced material which comprises forming a layer of an adhesive composition comprising a cellulosic derivative, a volatile solvent therefor, a high boiling solvent, and a plasticiser, depositing thereon attenuated fibers of a similar cellulosic derivative and indurating the adhesive layer by removing the volatile solvent.

7. A method of making a pile-surfaced material which comprises forming a layer of an adhesive composition comprising cellulose acetate, acetone ethylene glycol mono-methyl ether and a plasticiser, depositing thereon attenuated fibers of cellulose acetate and indurating the adhesive layer by removing the acetone.

8. A pile-surfaced sheet material comprising a layer of indurated adhesive substance and a pile consisting of attenuated fibers embedded at one end in said layer and physically homogeneous therewith.

9. A pile-surfaced sheet material comprising a layer of indurated adhesive substance and a pile consisting of attenuated fibers embedded at one end in said layer and physically and chemically homogeneous therewith.

10. A pile-surfaced sheet material comprising a layer of indurated cellulosic substance and a pile consisting of attenuated fibers of a cellulose derivative embedded at one end in said layer and physically homogeneous therewith.

11. A pile-surfaced sheet material comprising a layer of indurated plastic composition including cellulose acetate and a pile consisting of attenuated fibers of cellulose acetate embedded at one end in said layer and physically homogeneous therewith.

12. A pile-surfaced sheet material comprising a backing, a layer of indurated adhesive substance thereon and a pile consisting of attenuated fibers embedded at one end in said layer and physically homogeneous therewith.

13. A pile-surfaced sheet material comprising a backing, a layer of indurated plastic composition including cellulose acetate thereon and a pile consisting of attenuated fibers of cellulose acetate embedded at one end in said layer and physically homogeneous therewith.

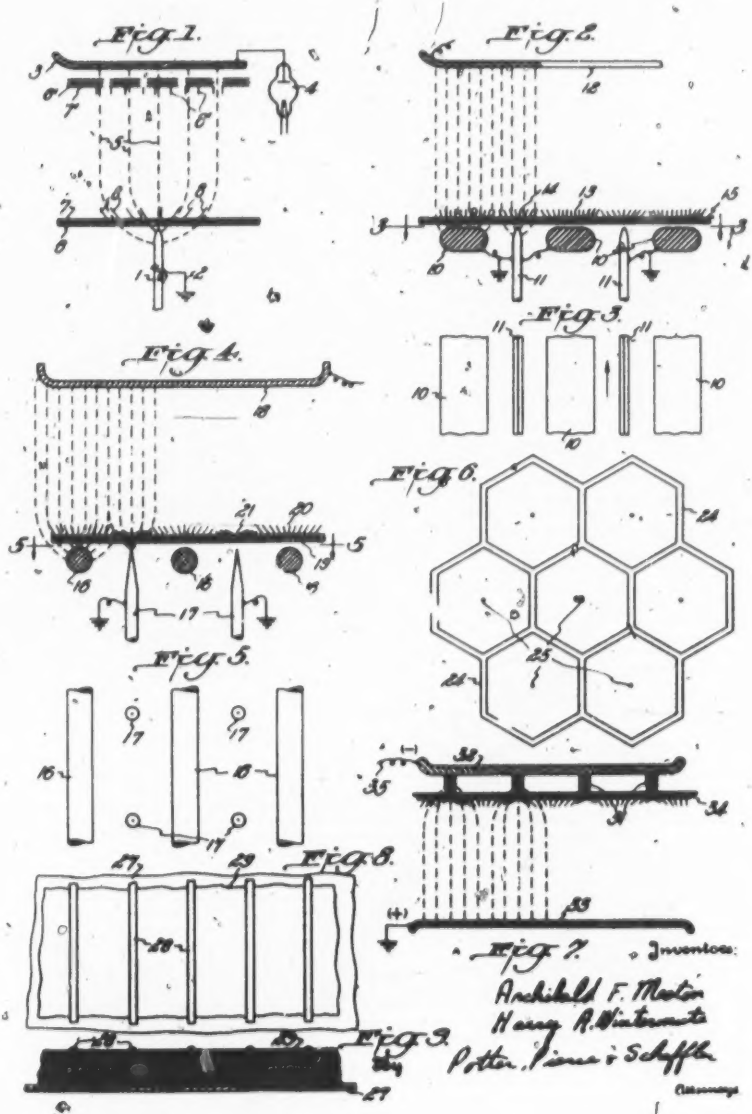
LOUIS P. MILLER.

[fol. 666]

March 28, 1939. A. F. MESTON ET AL 2,152,077

PRODUCTION OF FILED SURFACES IN PATTERN FORM

Filed Feb 6, 1935 4 Sheets-Sheet 1



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March 28, 1939. A. F. MESTON ET AL 2,152,077

PRODUCTION OF PILED SURFACES IN PATTERN FORM

Filed Feb. 6, 1935. 4 Sheets-Sheet 2

Fig. 10.

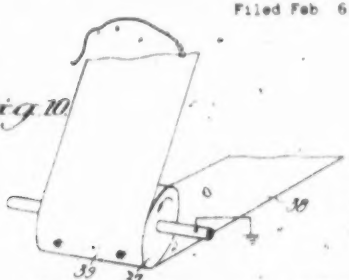
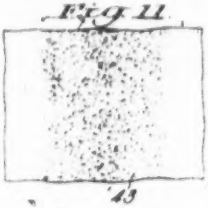


Fig. 11.



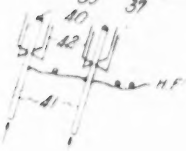


Fig. 12.

Fig. 13.

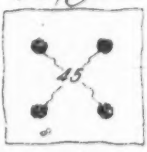


Fig. 14.

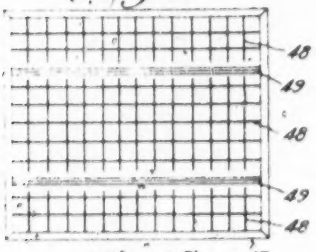


Fig. 15.

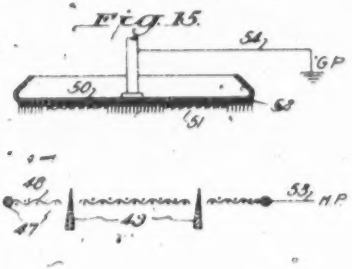


Fig. 16.

Fig. 17.

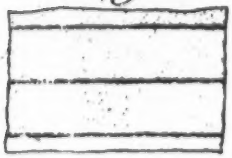
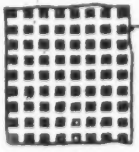


Fig. 18.



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[fol. 668]

March 28, 1939. A. F. MESTON ET AL 2,152,077

PRODUCTION OF FILED SURFACES IN PATTERN FORM

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Fig. 19.

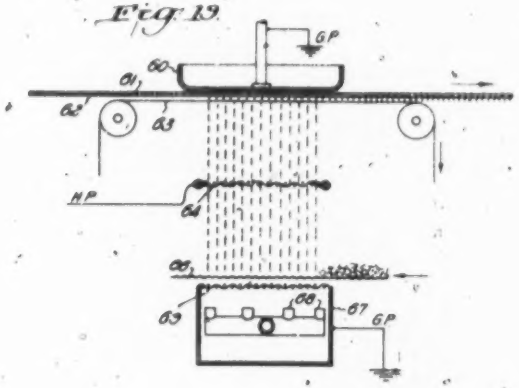


Fig. 20.

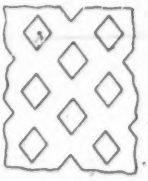


Fig. 21.

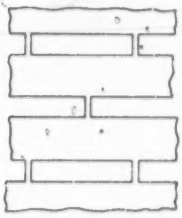


Fig. 23.

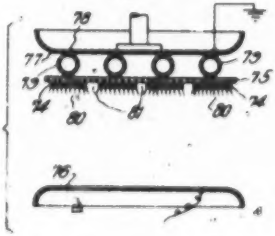
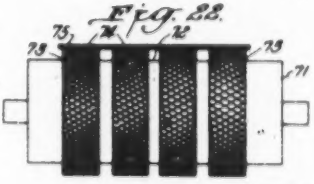


Fig. 22.



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PRODUCTION OF FILED SURFACES IN PATTERN FORM

Filed Feb. 6, 1935 4 Sheets-Sheet 4

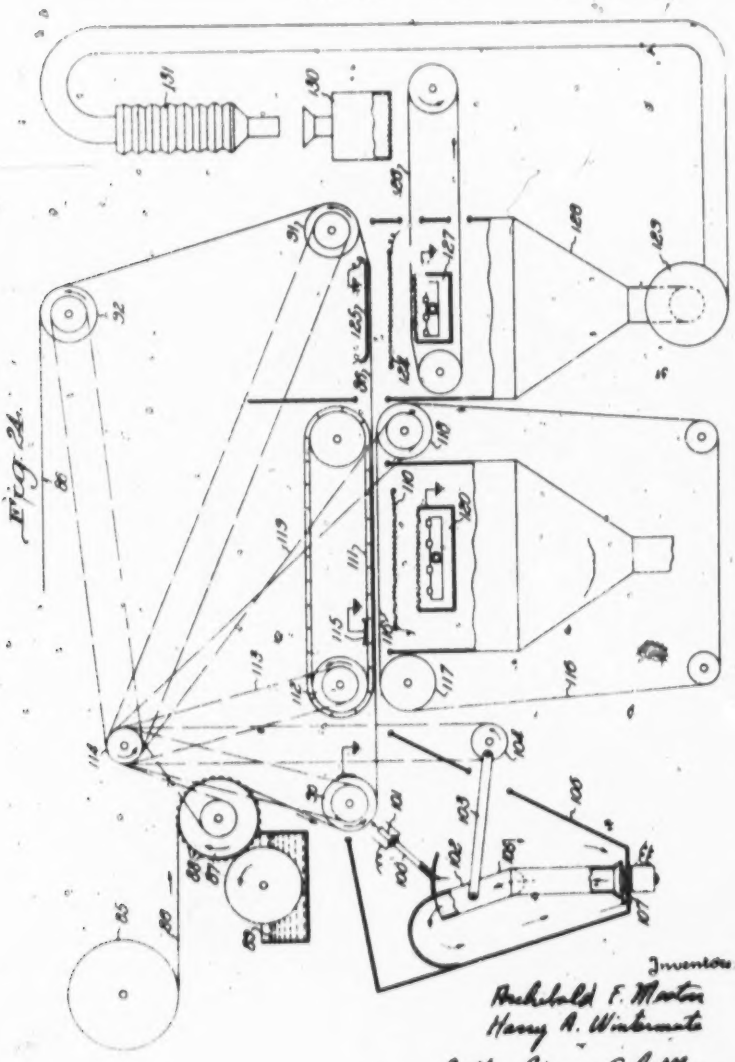

Fig. 24.

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[fol. 670]

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UNITED STATES PATENT OFFICE

2,152,077

PRODUCTION OF FILED SURFACES IN PATTERN FORM

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Application February 6, 1936, Serial No. 62,869

15 Claims. (Cl. 41—39)

This invention relates to coating and/or decorating surfaces with deposited piles in pattern form. It has to do in particular with apparatus and methods for making and controlling a non-uniform electric field used in the deposition of electrostatically charged particles on adhesive covered surfaces for the purpose of effecting a typical arrangement of the particles on the surfaces, for example, in pleasing patterns.

Fibers, such as rayon flocks, can be deposited in oriented position upon an adhesive covered surface if the surface is positioned in an electric field and fibers are introduced into the electric field in unrestrained manner. The conditions required for satisfactory deposition of fibers in the piling of surfaces are described in copending applications Serial No. 600,332, L. F. Miller, filed Sept. 30, 1932; Serial No. 602,561, A. F. Marion, filed Oct. 4, 1932; and Serial No. 660,496, H. A. Wintermute, filed Mar. 20, 1933.

The piles made with the apparatus and methods used and described in the applications just mentioned are quite uniform in composition and appearance. Most of the fibers stand erect, perpendicular to the surface, making piles of monotonous evenness from a decorative standpoint. It has now been found that by suitable control of the electric field by means of which the fibers are deposited, and particularly by the use of a deliberately warped or discontinuous electric field, pleasing variations and definite patterns can be obtained in the pile.

Apparatus useful in carrying out the invention and several embodiments of the invention, including novel materials and products, are hereinafter described with particular reference to the appended drawings, in which:

Fig. 1 is a diagrammatic side view of complementary electrodes and an electric field therebetween in which fibers are being attracted by the forces prevailing in a non-uniform portion of the field;

Fig. 2 is a fragmentary view in side elevation of an assembly of electrode elements as used in the deposition of fibers in accordance with the invention;

Fig. 3 is a fragmentary plan view of what is shown in Fig. 2 taken at 3—3;

Figs. 4 and 5 are fragmentary views comparable to Figs. 2 and 3, respectively, showing the utilization of somewhat different elements in the electrode structure used with the invention;

Fig. 6 is a plan view of another arrangement of electrode elements useful in setting up a non-uniform field in accordance with the invention;

Fig. 7 illustrates in side view the forming of a patterned pile on a base sheet with still another arrangement of electrodes;

Figs. 8 and 9 are fragmentary plan and side views, respectively, of another electrode assembly that can be used advantageously with the invention;

Fig. 10 indicates, perspectively, apparatus including air jets useful in applying fibers to surfaces in accordance with the invention;

Figs. 11, 12 and 13 show with plan views, the types of patterns which can be obtained with the apparatus illustrated in Fig. 10;

Fig. 14 is a plan view of a foraminous electrode, comprising screen forming elements, useful in practicing the invention;

Fig. 15 shows diagrammatically in end elevation, apparatus for utilizing the electrode shown in Fig. 14;

Figs. 16, 17 and 18 are views of fragmentary portions of products made with rotovalated electrodes;

Fig. 19 shows diagrammatically, in side elevation, apparatus for depositing fibers in pattern formation, by utilizing a moving field element;

Figs. 20 and 21 show typical forms of field elements used with the invention;

Fig. 22 illustrates, in side view, an adhesive applying roll with out-of-way portions;

Fig. 23 shows, in sectional elevation, an electrode assembly useful in depositing fibers on a surface coated with the roll shown in Fig. 22; and

Fig. 24 is a diagrammatic view in side elevation of apparatus that permits the utilization of the various electrodes and other means illustrated in the various figures and the carrying out of the several methods of the invention to be hereinafter described.

In Fig. 1, numerals 1 and 2 identify electrodes between which an electric field has been established; electrode 1 is grounded as indicated at 1' and electrode 2 is insulated from ground and connected to a source of high potential constant polarity current represented by tube rectifier 4. The so-called lines of force of the electric field represented by lines 3 leave the electrodes perpendicular to the surface. Electrode 1 has a pointed or rounded top and the lines of force curve [illegible] out in the manner shown as they [illegible] area presented by the top of the [illegible] opposing or complementary electrode 2. [illegible] other hand, has a flat surface upon which the lines of force terminate and the lines

of force in the vicinity of this electrode are straight, parallel, and uniformly distributed.

When a non-conducting sheet 6 covered with adhesive 7 is positioned between electrodes 1 and 2 and short fibers are freely suspended in the electric field the fibers are oriented and attached to the adhesive covered sheet parallel to the lines of force passing through the sheet at the point of attachment. Once attached they maintain the position of original attachment and resist realignment by forces that may be applied subsequently. When the sheet to be piled with fibers is placed in the position marked 6', the fibers are attached in the positions 8', 8' and a uniform pile of upright fibers is obtained. But if a sheet is held against, or a short distance from, electrode 1, the fibers are attached at angles to the perpendicular as indicated at 8, 8 because of the inclined positions of the lines of force 9 in this region of the electric field. For instance, the field near a point causes the fibers to become arranged like the petals of a flower.

In Figs. 2 and 3, the electrode elements over which the adhesive covered sheet 16 is positioned while being piled comprises members 10 with a more or less extended top surface and members 11 with very restricted or edged top surfaces. The complementary electrode 12 is preferably flat or has an extended surface. The arrangement of the fibers in the pile made with the electric field between electrode elements 10 and 11 and electrode 12 is shown in Fig. 2. The fibers 13 over the extended portions 10 are deposited in erect position except perhaps over the edges of elements 10, while the fibers 14 over edges 11 are deposited in the inclined positions shown and provide a striped effect. This pattern can be made while the sheet is moving in the direction of the arrow in Fig. 3, but if it is desired to have the stripes extend crosswise of the sheet, the electrode elements 10 and 11 must move at the same speed as the sheet.

In Figs. 4 and 5 the electrode assembly which influences the deposition of the fibers is made up of bars 16 and pointed members 17. Complementary electrode 18 has a flat extended surface. The pile formed with these electrode elements, assembled as shown, comprises parallel stripes with spots between them, the stripes being formed of fibers 20 deposited over rods 16 perpendicular to sheet 19 except at the edges and the spots being formed of fibers 21 which are deposited over points 17 in inclined positions. The smaller the diameter of rods 16 and the closer these are to the sheet 19 being piled, the more the fibers at the edges of the stripes lean outward and set off the stripes, and the closer points 17 are to sheet 19 the more pronounced is the inclination of the fibers in points 21.

By varying the relative positions of the electrode elements in Figs. 4 and 5 the pattern formed will present various effects. The electrical connections can be varied also. It will be noted that while elements 10 in Fig. 2 are grounded, elements 16 in Fig. 4 are not connected to ground, but are allowed to electrically "float" on insulating supports (not shown) and to take the voltage resulting from their position in the electric field. If the sheet being piled is held stationary during the deposition of the fibers the pattern will comprise stripes with dots between, but if the sheet is moved during deposition the electrode elements, at least points 17, must move at the same speed as the sheet or streaks will result in the pattern over the points.

Fig. 8 is a plan view of an assembly of electrode elements not unlike the assembly shown in Fig. 5, but in Fig. 8 the bars (similar to those marked 16 in Fig. 5) making up member 24 have been joined together to form a single continuous element. Points 25, one of which is positioned in the center of each individual hexagon, have been found to alter the electric field in such manner that the pile deposited by it comprises hexagon figures of unusual interest. The fibers are inclined at various angles and when looking at the pile from first one and then another position the sheen changes, displaying many fragments of hexagons, some lustrous and some of which are dull. Of course, to provide a closed pattern like the one made with the electrode of Fig. 6, the electrode must participate in any movement undergone by the surface being piled, as will be described, for example, in connection with Fig. 24.

In Fig. 7, elements 31 are strips of insulating material, for instance, of hard rubber or phenol condensation products, attached to a conducting plate 32. Dielectric material with a specific inductive capacity several times that of air, examples of which are porcelain, mica or "Bakelite", when placed in an electric field, will locally concentrate the lines of force in the field in the vicinity of the pieces of dielectric. The arrangement shown in Fig. 7 has conducting plate 32 connected through conductor 35 to a source of unidirectional current at a potential of, say, 70,000 volts above ground. Complementary electrode 33 is positioned some 4 inches below member 32 and is maintained at ground potential. Elements 31 are, therefore, positioned in the strong electric field that exists between electrodes 32 and 33 and tend to concentrate the lines of force as they approach electrode 32.

Now if an adhesive covered surface, as sheet 34, that is not conducting, is placed just in front of elements 31 and fibers are suspended in the electric field above electrode 33, or distributed over the surface of electrode 33, many of the fibers will be raised and oriented by the electrical field and attracted to electrode 33. The fibers will move with their long axis parallel to the electric lines of force and become attached to the adhesive covered under surface of sheet 34 in the inclined positions shown. In this embodiment of the invention the electric field is warped by placing insulating members of sharp curvature or limited area before a conducting member, preferably a simple member of extended area, whereas in the apparatus illustrated in Figs. 1, 2, 4 and 6, warped fields are established by providing conducting elements of sharp curvature and limited area. The insulating strips 31 in Fig. 7 can be formed into geometrical figures, letters and the like, thus permitting a wide variety in the patterns formed.

Figs. 9 and 9 illustrate another electrode structure comprising insulating material used with certain embodiments of the invention. It is made up of a conducting base plate 37, conducting elements 38, here shown as narrow strips with rounded tops, and dielectric material 39 between the strips. Electrodes of this construction give very striking results. The sheet to be piled is placed parallel to the top surface of material 39 and touching or closely adjacent the top (exposed) edges of members 38 and a complementary electrode is positioned at a proper distance—

[fol. 672]

2 to 3 inches, depending upon conditions—above 20 as electrode 19 is positioned above members 16 in Fig. 2. The pile deposited when a strong electric field is established between the electrodes shows very pleasing shaded stripes, probably due to peculiar disturbances in the electric field produced at top of electrode 20 where they emerge from insulating material 24. The arrangement of the conductive members with relation to the insulating material has been found to have a considerable effect on the patterns produced. With the electrode shown in Figs. 6 and 8, very good patterns have been obtained with conductive edges 20 projecting about $\frac{1}{32}$ to $\frac{1}{16}$ inch above the surface of dielectric filler 24.

In these embodiments of the invention shown in Figs. 1 to 9, inclusive, the controlling electrode, that is the electrode influencing the pattern in the pile most greatly, is placed just back of the sheet or other member, the surface of which is to be piled. The adhesive coating is placed on the side of the sheet away from the controlling electrode and faces the complementary electrode which furnishes a surface upon which the other end of the electric field terminates. For example, in Fig. 4, elements 16 and 17 comprise the controlling electrode, member 18 is the complementary electrode, and 19 is the sheet being piled with the adhesive coating on the side of the sheet away from electrode 16, 17. Figs. 6, 8 and 9 show no complementary electrodes, but it is to be understood that in using the controlling electrodes shown in these figures, suitable opposing or complementary electrodes are also used. The electrodes can be positioned so that the fibers move downward to become attached to the coated surface, as in Fig. 2, or the electrodes can be arranged to cause the fibers to move upward as in Fig. 7. The latter arrangement, or an arrangement with vertically positioned surfaces, is advantageous because such arrangements make easy the jarring of loose and poorly attached fibers from the sheet during the piling operation.

The electrode farthest from the sheet is not of such contour, usually, that it influences the pattern in the pile and is often made as a simple, flat, non-discharging surface. But as will be explained hereinafter, the electrodes away from the sheet to be piled can greatly influence the deposition of the fibers comprising the pile.

The sheet to be piled in Fig. 10 is positioned adjacent an electrode of smooth contour, in this instance, a roll 27 and screen-forming complementary electrodes 28 are responsible for the pattern effect in the pile. It has been found that if the fibers to be electrically deposited are introduced through a tube about which corona discharges are present, desirable results in patterned piles can be obtained. In Fig. 10, sheet 29 travels about a grounded roll 27 which preferably turns to avoid friction and supports an adhesive covered surface 30 to electrodes 28, each made up of a tube 31 and discharge points 32. It has been found that if wire points 32 are bent at right angles and another fibers are blown through tubes 31 and the tubes are connected to a source of unidirectional high potential current, the fibers become positioned as they are deposited. Such a result is shown at 33 in Fig. 11. With points 32 attached to and arranged about high potential tubes 31, the fibers are concentrated locally as illustrated in Figs. 10 and 11. If sheet 29 moves while electrodes 28 are stationary, but continuously depositing fibers, stripes 34 are formed. If the fibers are deposited only while sheet 29 is stationary, or while it is moving at the same speed as electrodes 28 are caused to move, spots are formed such as those marked 35 in Fig. 12. Other factors controlling the pattern produced are the size of the tubes or nozzles, the velocity of the air stream, the emphasis given the corona emanating from the points as caused by variously positioning the points about the end of the tube, and the strength of the electric field.

The stripes or points deposited with the electrode assembly in Fig. 10 may be localized in themselves to form a pleasing pattern. Advantageously all of surface 30 is covered with adhesive, then spots are first deposited in one color in the manner just described, and then the sheet is moved into another part of the apparatus shown in Fig. 10 where the applied surface is covered with fibers of a different color. Not only can the fibers successively deposited be of different colors, but they can be of different length and/or luster, and by controlling the characteristics of the electric field and the length of treatment the spots or stripes can be made to have a very different appearance from the pile filled in between. The furs of certain animals, the silver fox, for instance, can be imitated by using the method just described.

It has been found desirable in the electrical attachment of fibers to form a pile to have the fibers approach the surface to be piled separately, not in clumps or "tufts" together. Screens may be used to break up grouped fibers as they are floated in air streams into the electric field and a simple manner of using a screen or other foraminous member for this purpose is to have it function as one of the electrodes. Figs. 14 and 15 show an electrode 47 that functions as a complementary electrode to grounded electrode 48. Electrode 47 of conducting material is insulated from ground and positioned about four inches below electrode 48 and is connected by conductor 49 to a source of unidirectional high potential current. It functions also to break up clumps of fibers blown by air jets 50 from supply means 51 that are not completely disintegrated by disintegrating means 52. It has been discovered that a foraminous electrode, positioned and used as is electrode 47 in Fig. 15, can be caused to influence the arrangement of fibers as they are electrically deposited on a surface,—as the surface of sheet 53, for example, as it is held adjacent 48. One way of altering the pile formed of the deposited fibers is to make foraminous electrode 47 with edges 46 projecting through surface 45 which is preferably of screen. The electric field adjacent edges 46 is so concentrated when a high voltage drop is impressed across electrodes 47 and 48 that corona discharges emanate from the edges and the fibers just over the edges deposit in other than even positions as indicated at 54. Improved piling effects are given the pile formed with electrodes 47 and 48. Of course, points or edges arranged in patterns could be substituted for edge members 46 in electrode 47.

Figs. 16, 17 and 18 are plan views of fragments of patterned piles which may be made with the controlling electrodes spaced from the surface being piled. The pattern shown in Fig. 16 is made with an electrode of wire mat of coarse mesh ($\frac{1}{16}$ to $\frac{1}{8}$") located in the position of electrode 47 in Fig. 15. A very strong electric field is used to deposit the fibers, but not strong enough to force the fibers down into the adhesive, such as results from spots desirable across discharges. The pile in Fig. 17 results from the use of an electrode

comprised of parallel wires and that shown in Fig. 18 may be made with a net of rather small mesh used as a controlling electrode and positioned several inches from the adhesive covered surface being piled. The piles shown in Figs. 16, 17 and 18 are characterized by having lines and/or dots standing out prominently as local concentrations of fibers.

Fig. 19 illustrates apparatus in which the field controlling member is supported in front of the surface being piled, but is preferably at the same or nearly the same potential as the electrode just back of the sheet with the surface being piled. Electrode 66 is preferably flat and is at ground potential. Electrode 64 is of reticulated construction or the like and is maintained at high potential. Sheet 61, the under side 62 of which is to be piled, is moved through the electric field between electrodes 66 and 64, preferably just under and touching electrode 66, as shown. A member 63, advantageously formed as a belt with stencil-like perforations such as the diamond design shown in Fig. 20 or the slots shown in Fig. 21, is moved parallel with and at the same speed as sheet 61. It is held a short distance, for example one-fourth inch, in front of adhesive covered surface 62. The fibers to be deposited are brought into the apparatus on a moving porous belt 65. When the fibers are carried by belt 66 over the top of wind box 67, compressed air issuing from nozzles 68 and passing through regulating means 69 blows through the interstices of belt 66 and blows the fibers up through electrode 64 and into the electric field for deposition on surface 62. Very definite patterns are made with the apparatus shown in Fig. 19 and they can be made very colorful if the sheet to be piled is passed through several partially shielded fields, each one depositing fibers of a different color.

Belt 63 can be made of wire or other attenuated members woven into a pattern and it will influence the deposition of the fibers comprising the pile by altering the electric field. The resulting patterns will be much like those shown in Figs. 16 and 17, but in more striking relief. Or belt 63 can be made up as a stencil and cause a pattern to be made by definitely covering portions of surface 62 and permitting flocks to be deposited only behind openings in the stencil. Besides the diamond pattern shown in Fig. 20, decorative designs, such as flowers, and commercial outlines comprising names, can be formed. Such stencil-like members affect the pattern not only mechanically but also affect it by locally altering the characteristics and intensity of the electric field and therefore they may be designated as "field stencils".

Figs. 22 and 23 illustrate apparatus adapted to apply adhesive locally to a surface and then to pile the adhesive covered portions in accordance with the invention. In Fig. 22, adhesive applying roll 71 has cut away portions 72 and raised portions 73. Only the raised portions carry adhesive to the surface to be piled and in the figure a transverse cross-section of a sheet 76 is shown with strips of adhesive 75 applied thereto by raised portions 73. Fig. 23 shows sheet 76 after having been locally coated with adhesive with roll 71 passing through a strong electric field between complementary electrodes 78 and 77. Electrode 77 comprises a conducting plate 79 on the bottom surface of which tubes 76, or other members of small surface area which may be but are not necessarily conducting, are attached. Tubes 76 are spaced to correspond with the spacing of raised portions 73 on applicating roll 71. Sheet 76 is positioned under and adjacent tubes 76 and, for continuous operation, is moved in a direction parallel to the tubes. The pile 80 deposited on adhesive strips 74, by action of the electric field in the manner previously described, is not uniformly erect, but leans outwardly at the edges and projects into unpiled spaces 81. The inclined positions of some of the fibers is due to the directions taken by the lines of force of the electric field approaching the surfaces of tubes 76. The effect of the inclined fibers partially covering spaces 84 is especially striking when the fibers are of one color and sheet 76 is of another color.

Fig. 24 is a diagrammatic view in side elevation of apparatus which may be used to successively applying the several embodiments of the invention which have been described. A sheet 86 of the material to be piled, for example, a light weight, flexible but closely woven textile, is unwound from supply roll 86, passed over an adhesive applying roll 87, over positioning and tensioning rolls 89, 91 and 92, and through means, not shown, for finishing and storing the piled product. Roll 87 is shown with raised portions 88 to apply the adhesive from vessel 89 to the surface of sheet 86 in restricted areas only as in that embodiment of the invention illustrated by Figs. 22 and 23. Where the surface of the sheet is to be completely piled, a smooth roll to spread adhesive over the entire surface of the sheet is used.

As the adhesive coated sheet goes over roll 92, it may be sprayed with fibers from one or more spray electrodes 101 in accordance with the practice described in connection with Figs. 10, 11, 12 and 13. If the spray electrodes 101 are operated continuously, lines of fibers are deposited upon sheet 86 as shown in Fig. 12, but if the spraying is done at intervals only, spaced patches such as the spots shown in Fig. 13 will be deposited. The fibers for sprays 101 are supplied through conduit 102 and this can be made to move away from the entrance of sprays 101 by reciprocating means, for instance, crank 107 acting, preferably with a quick return movement, through connecting rod 108 will make conduit 102 articulate at joint 109 at the chosen intervals when deposition of particles is to be interrupted. During the period of interruption the fibers blow out the end of conduit 102 and fall to the bottom of casing 103 to be lifted again by blower 101. If electrode 104 is maintained at high potential connecting tube 102 is made of insulating material.

Sheet 86 next passes through an electric field established between spray electrode 110 and control electrode 111 by means of a high voltage source not shown. The latter electrode can be in the form of any of the control electrodes shown in Figs. 1 to 9, inclusive, but is made tube or is attached to an endless band. If electrode 111 is to cause the fibers to deposit in a chosen pattern or one that intermittently varies, it must move at the same speed and in the same direction as sheet 86 while sheet 86 is moving through the electric field above electrode 110. This is accomplished by having pulley 112, over which electrode 111 passes, by a positive drive 113 such as a chain from a source of power 114 which also turns pulley 86 over which sheet 86 passes, in positive manner. Positive synchronous movement of belt and electrode can also be obtained by having spurs project from the edge of electrode 111 and engage perforations along the edges of sheet 86 in the manner known to the moving picture art.

[fol. 674]

A grounded shoe 118 contacts electrode 111 and maintains it at ground potential.

Underneath sheet 86 a belt 116 may be positioned by utilizing supporting pulley 117 and supporting and propelling pulley 118. Belt 116 may be perforated as a stencil and function as a field stencil in the manner of member 66 in Fig. 10. The stencilling belt might move at the same speed as sheet 86 and such movement is obtained through drive 119. Other field altering means, such as screens, can be used in place of stencilling means 116, and such means travelling at the speed of sheet 86 will give the pile on sheet 86 a woven appearance as indicated in Figs. 16 and 18. Although pattern control electrode 111 and stencilling or other field altering means 116 can be used at the same time, ordinarily this is not done. A flat stationary electrode may be used in place of special electrode 111 when a field stencil is being used in front of sheet 86. Fibers are supplied to the field between electrodes 110 and 111 by supply means 120 in which air jets are utilized to project the fibers up through electrode 110.

Electrodes 124 and 125 in Fig. 24 are energized and used to deposit fibers if portions of the surface of sheet 86 remain unpiled after the sheet passes through the processing steps described in the above. No special effort is sought in this last step. Both electrodes have, in general, flat surfaces and the uniform field that results from impressing a high voltage across electrodes 124 and 125 tends to deposit an erect uniform pile. The deposition of fibers in this step is usually for the purpose of completing the pile started with spray electrodes 101 and/or the pile deposited through field stencil 116 and this filling in often made with fibers of a different color from that used in the preceding steps.

Apparatus for satisfactorily supplying fibers to the field between electrodes 124 and 125 is shown diagrammatically under electrode 124. It comprises an endless foraminous conveying belt 126 upon which fibers are spread by a distributor 130, preferably agitated, and a blowing means 127 that distributes air under pressure under belt 126 and causes it to pass up through the belt and raise the fibers therefrom and blow them through screen electrode 124. Undeposited fibers are collected in hopper 128 and conveyed by an air stream set in motion by fan 129 to filter bag collector 131 and thence to distributor 130.

Fig. 24 illustrates apparatus with a wide range of usefulness in the forming of simulated piles on adhesive covered surfaces. It is illustrative of the wide variation in methods and means for obtaining useful patterns in the electrical deposition of pile forming materials by the local alteration of the characteristics of the electrical field effecting the deposition, so as to produce a definite typical non-uniformity therein. It is obviously subject to a very large degree of variation and may be provided with electrode rapping or agitating means and other devices and modifications.

We claim:

1. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, one of said electrodes being formed to cause local variations in the concentration of the electric field between said electrodes, means for passing an adhesive-surfaced base material through the non-uniform portion of said field, means for moving said named electrode substantially synchronously with said base material, and means for supplying attenuated fibers to said field.

2. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of elements of different electrical characteristics providing, when viewed from the complementary electrode, a surface locally varied to produce in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and means for supplying attenuated fibers to said field.

3. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of elements varying in radius of curvature to produce in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and means for supplying attenuated fibers to said field.

4. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of different specific inductive capacity producing in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and means for supplying attenuated fibers to said field.

5. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of small radius of curvature spaced from the complementary electrode and producing in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and means for supplying attenuated fibers to said field.

6. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of small radius of curvature spaced from the complementary electrode and producing in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and at least

one of said electrodes comprising a conduit for supplying attenuated fibers to said field.

7. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of small radius of curvature spaced from the complementary electrode and producing in the electric field between said electrodes local concentrations, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and said electrode having members of small radius of curvature comprising a conduit for supplying attenuated fibers to said field.

8. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of small radius of curvature spaced from the complementary electrode and producing in the electric field between said electrodes ionic streams, means for positioning an adhesive-surfaced base material in the portion of the field comprising said ionic streams, and means for supplying attenuated fibers to said field.

9. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes comprising a plurality of members of small radius of curvature spaced from the complementary electrode and producing in the electric field between said electrodes localized ionic streams, means for positioning an adhesive-surfaced base material in the portion of the field comprising said ionic streams, and means for supplying attenuated fibers to said field.

10. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes having local variations in electrical characteristics of the material forming said electrode whereby the electric field between said electrodes is caused to comprise locally concentrated portions, means for positioning an adhesive-surfaced base material in the non-uniform portion of the field, and means for supplying attenuated fibers to said field.

11. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween, at least one of said electrodes having local variations in specific inductive capacity of the material forming said electrode whereby the electric field between said electrodes is caused to comprise locally concentrated portions, means for positioning an adhesive-surfaced base material in the non-uniform portion of the field, and means for supplying attenuated fibers to said field.

12. A method for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form which comprises establishing an electric field having locally concentrated portions, positioning an adhesive-surfaced base material in the non-uniform portion of said field, and supplying attenuated fibers to said field thereby depositing the fibers on said base material in pattern form.

13. A method for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form which comprises establishing an electric field having locally concentrated portions, positioning an adhesive-surfaced base material in the non-uniform portion of said field, supplying attenuated fibers to said field thereby depositing the fibers on said base material in pattern form, thereafter positioning said base material in a substantially uniform electric field, and supplying fibers of different appearance from said first deposited fibers to said field.

14. A method for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form which comprises establishing an electric field having locally concentrated portions, passing an adhesive-surfaced base material through the non-uniform portion of said field, supplying attenuated fibers to said field thereby depositing the fibers on said base material in pattern form, thereafter passing said base material through a substantially uniform electric field, and supplying fibers of different appearance from said first deposited fibers to said field.

15. A method for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form which comprises establishing an electric field having locally concentrated portions, passing an adhesive-surfaced base material through the non-uniform portion of said field, supplying attenuated fibers to said field thereby depositing the fibers of said base material in pattern form, thereafter passing said base material through a second field constituted differently from said first field, and supplying fibers of different appearance from said first deposited fibers to said field.

ARCHIBALD F. MENTON.
HARRY A. WINTERSMITH.

[fol. 676]

July 18, 1939. H. A. WINTERMUTE 2,166,385

DETERMINING ELECTRICAL CHARACTERISTICS

Filed April 10, 1937

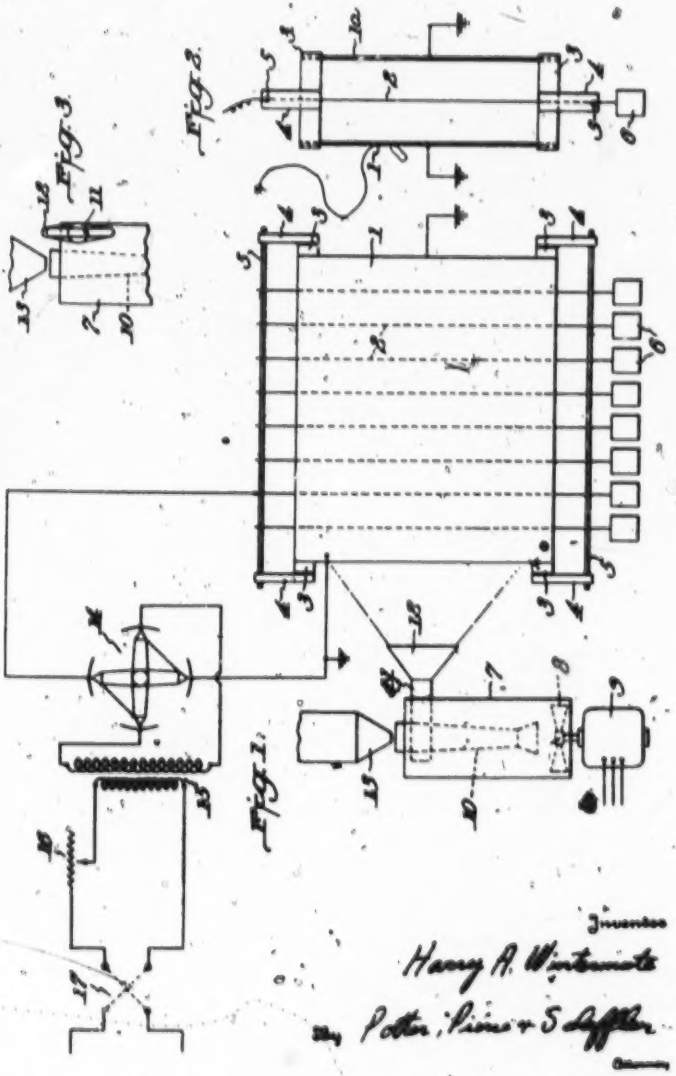

Fig. 2.

Fig. 3.

Fig. 1.

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Patented July 18, 1939

2,166,385

UNITED STATES PATENT OFFICE

2,166,385

DETERMINING ELECTRICAL CHARACTERISTICS

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Application April 10, 1937, Serial No. 136,232

9 Claims. (Cl. 175—183)

This invention relates to a method of determining the electrical characteristics of finely divided materials, particularly fibrous materials of relatively high electrical resistance, for example, rayon flock, cotton fibers and the like.

It is particularly desirable in the utilization of finely divided fibrous materials to form piled surfaces by electrical deposition of the fibrous materials on a surface, to be able to determine in advance the electrical characteristics of the materials to be deposited, or to be able to determine the conditions, for example of temperature and relative humidity at which a material exhibits the most favorable electrical characteristics for the purpose in hand.

A principal object of the invention is to provide a method for testing the electrical characteristics of finely divided materials.

A further object is to provide a method for the determination of the conditions under which the electrical characteristics of a material are at an optimum or have a predetermined value or are substantially equivalent to the electrical characteristics of a preselected standard material.

It has been found that these and other objects of the invention may be attained by causing a portion of the material to be tested to adhere to a surface under the influence of an electric charge imparted to the material and determining the rate at which the material loses the imparted charge.

An advantageous method of imparting a charge to the material comprises dispersing the material in air or other medium, and passing the dispersed material into an electrical field between a discharge member and a relatively extended surface whereby the material is deposited on the extended surface and a charge is imparted to the material.

The rate at which the imparted charge is lost may be determined by means of an electroscope or by determining the time required for the charge to fall to such a value that the deposited material will fall under the influence of gravity when the collecting surface is placed, for example, in a vertical position.

In the production of pile-surfaced materials by the deposition of finely divided fibrous materials, such as rayon flock, it has been found that in general the materials which exhibit a relatively high rate of leakage of the imparted charge are of particular value in the production of pile fabrics. It has also been found that materials showing similar rates of leakage are, in general, similar in their action in the production of piled surfaces. It has further been found that the rate of leakage and, correlative therewith, the satisfactoriness of deposition in the pile-forming process, may be varied by varying the condition of the material. The temperature and the relative humidity have been found to be of particular effect upon the rate of leakage of an imparted charge from finely divided material and the method of the invention provides an advantageous means for determining the optimum conditions, for example, of temperature and relative humidity under which the electrical deposition process may be carried out.

The invention will be more particularly described with reference to the accompanying drawing of an illustrative form of apparatus for use in practicing the invention.

In the drawing:

Fig. 1 is a partly diagrammatic elevation of apparatus suitable for practicing the invention;

Fig. 2 is an end elevation of the charging device of the apparatus of Fig. 1; and

Fig. 3 is a fragmentary end elevation of the dispersing device of the apparatus of Fig. 1.

In the figures, 1 and 1a are vertical plate electrodes of conducting or semi-conducting material supported by members 3, and 2 are attenuated discharge electrodes carried by supporting members 5 mounted on insulators 4. The discharge electrodes are steadied by weights 6. The electrodes are energized by high voltage unidirectional current from mechanical rectifier 14 connected with the secondary of transformer 15. 16 is a resistance for voltage control and for ballasting the circuit and 17 is a reversing switch for controlling polarity of the charge.

The material to be tested is dispersed in a disperser 7, having a fan 8, driven by motor 9, for forming a current of air or other gas. The material is supplied from hopper 13 into tube 10 which carries the material to the bottom of the dispersing chamber and also forms an inlet for the current of air. The air current carrying the dispersed material passes out of tangential outlet 11, through the fan shaped nozzle 12 into the space between plates 1 and 1a.

In operation, the finely divided materials to be tested are broken up into individual particles and dispersed in the gas stream by means of the disperser 7. The gas stream leaves the disperser via the tangential outlet 11, entering the fan shaped nozzle 12. The gas carrying the finely dispersed particles leaves the nozzle 12 in a relatively narrow stream and enters the space be-

[fol. 678]

tween the two plates 1 and 1a. Here the particles are subjected to the influence of the electric fields between the discharge electrodes 2 and the conducting plate members 1 and 1a.

As the particles travel through the space between plates 1 and 1a the particles are charged by the electric field in which they find themselves principally by the corona discharge emanating from the discharge electrodes. The particles as they are charged move to the plates to which they cling as long as the plates and wires are energized. Operation is continued until a mat of fibers has been deposited on each plate varying from a few mils up to a depth of an inch or more.

As long as the apparatus is energized, additional electric charge is supplied to the mat of fibers as fast as the charge on the fibers leaks off. However, as soon as the source of energy is disconnected the fibers begin to lose their charge by flow of current through the mat. The time required for the charge to leak off sufficiently for the mat to fall varies with the conductivity of the fibers. For high conductivity they may cling only a fraction of a second after the energy source is disconnected or for very low conductivity they may cling for several hours.

The charged particles attracted to the plate electrode are not repelled upon approaching the plate because the discharge from the discharge electrode furnishes additional charges of constant polarity to the particles as fast as the charges on the particles leak off to the plate. When the discharge electrode is disconnected from the source of energy, the particles will cling to the plate electrode for a long time if the paths over or through the particles and across their loose and limited contact with the surface of the plate are not sufficiently conducting to permit the charges on the particles to flow readily to the surface of the plate and be neutralized by the charges of opposite polarity thereon, and the rate at which a charge from the plate will flow out over the surfaces of the particles, bringing about a repelling action, will be very low when poorly conducting paths only are provided.

The opposing electrodes can be energized in numerous ways. However, for most cases satisfactory energization can be secured by means of a high voltage transformer and a synchronous mechanical rectifier connected between the transformer and the opposing electrodes.

Particles not charged are carried on through the dust and are not deposited on the plates. For best results, the gas carrying the finely divided material is fed into the space between the opposing electrodes in a stream relatively narrow with respect to the dust so that there will be no influence of the gas stream on the precipitated mat of fibers.

An illustrative example of a method of testing embodying the principles of the invention is as follows:

Forty grams of white cotanose rayon flock were dispersed in air at a dry bulb temperature of 100° F. and a relative humidity of 30%. The dispersion was passed between two flat vertical plates about 45 inches long and 30 inches high spaced 7¼ inches apart, having a plurality of wire discharge electrodes positioned midway between them. An electrical field was maintained by means of a unilateral potential of 30,000 volts impressed between the discharge electrodes and the plates. The voltage was maintained for several minutes after the material had deposited on the plates to insure uniformity of charging.

The time required for the deposited material to fall from the collecting plates was 72,840 seconds. When a further sample was deposited at the same temperature and at a relative humidity of 67%, the deposited material fell from the collecting plates in 420 seconds.

A sample of white viscose rayon tested at a dry bulb temperature of 86° F. and a relative humidity of 65% fell from the collecting plates in 1 second.

While the invention has been more particularly described for the purpose of illustration, with reference to the testing of fibrous materials for use in the production of pile-surfaced materials, it is not limited thereto but may, in general, be advantageously applied when it is desired to determine the electrical characteristics of other finely divided materials of relatively low conductivity.

This application is a continuation-in-part of my application Serial No. 51,719, filed November 26, 1935.

I claim:

1. Method of testing finely divided fibrous materials which comprises causing a sample of the material to adhere to a surface by means of an electrical charge impressed thereon and determining the time required for the material to fall from the surface under the influence of gravity.

2. Method of testing finely divided fibrous material which comprises electrically depositing a sample of the material on a surface and determining the time required for the material to fall from the surface under the action of gravity.

3. Method of testing finely divided fibrous material which comprises electrically depositing a sample of the material on a surface and determining the conditions under which the material will fall from the surface under the action of gravity in a predetermined length of time.

4. Method of testing the electrical conductivity of finely divided materials of relatively low conductivity which comprises dispersing a sample of the material in a gaseous medium, impressing an electrical charge on the dispersed material, and determining the rate at which the dispersed charge is lost.

5. Method of measuring the effect upon finely divided materials of humidity and temperature conditions which comprises subjecting a sample of the material to predetermined conditions of humidity and temperature, causing the sample to adhere to a surface by means of an electrical charge impressed upon the sample and determining the rate at which the charge is transferred from the sample to the surface.

6. Method of testing the electrical characteristics of finely divided material of relatively low conductivity which comprises dispersing the material in a gaseous medium, electrically depositing the material on a surface by the action of an electric field, discontinuing the electric field, and determining the time required for the material to fall from the surface under the action of gravity.

7. Method of testing the electrical characteristics of finely divided materials of low conductivity which comprises subjecting the materials to a corona discharge to impress an electrical charge thereon and determining the rate at which the impressed charge is lost.

8. Method of testing the electrical characteristics of finely divided materials of low conductivity which comprises subjecting the materials

to a corona discharge to impress an electrical charge thereon and determining the conditions of the atmosphere in contact therewith under which the impressed charge is lost at a predetermined rate.

9. Method of testing the electrical characteristics of finely divided materials of low conductivity which comprises subjecting said materials to a corona discharge in an electric field to cause the material to adhere to a surface, and determining the time required for adhesion of the material to the surface to be lost after discontinuance of the electric field.

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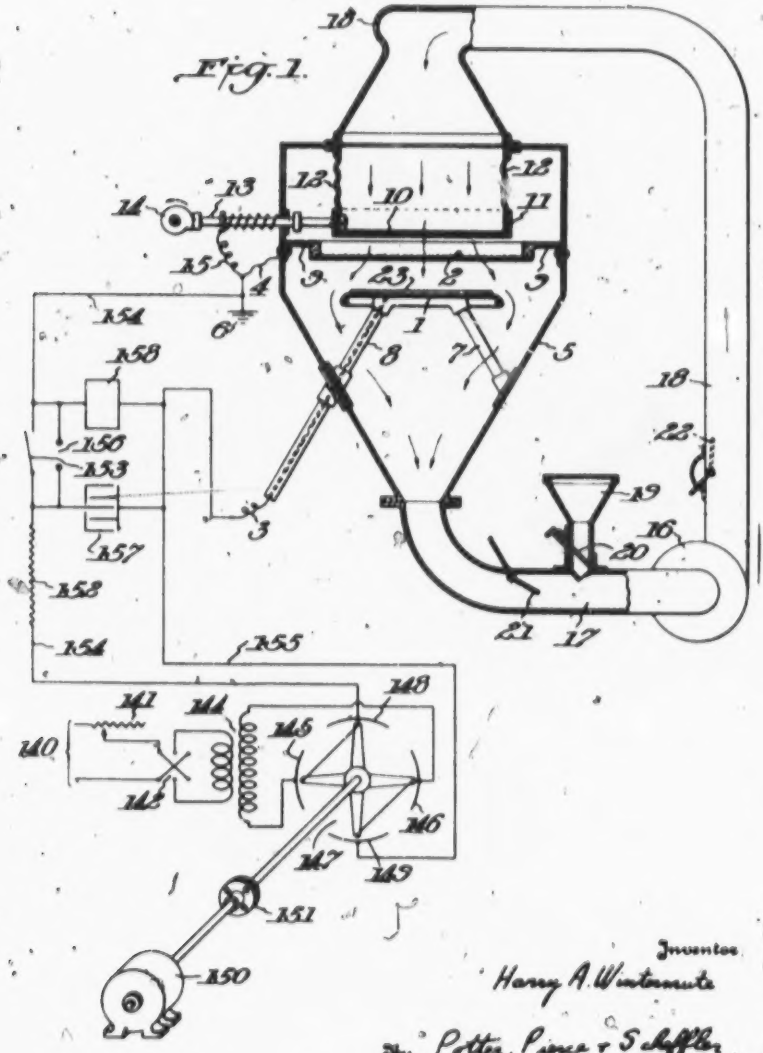
[fol. 680]

Sept. 12, 1939. H. A. WINTERMUTE 2,173,032

PRODUCTION OF FILE SURFACED MATERIALS

Filed Nov. 23, 1933 3 Sheets-Sheet 1

Fig. 1.



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[fol. 681]

Sept. 12, 1939. H. A. WINTERMUTE 2,173,032

PRODUCTION OF PILE SURFACED MATERIALS

Filed Nov. 23, 1933 3 Sheets-Sheet 2

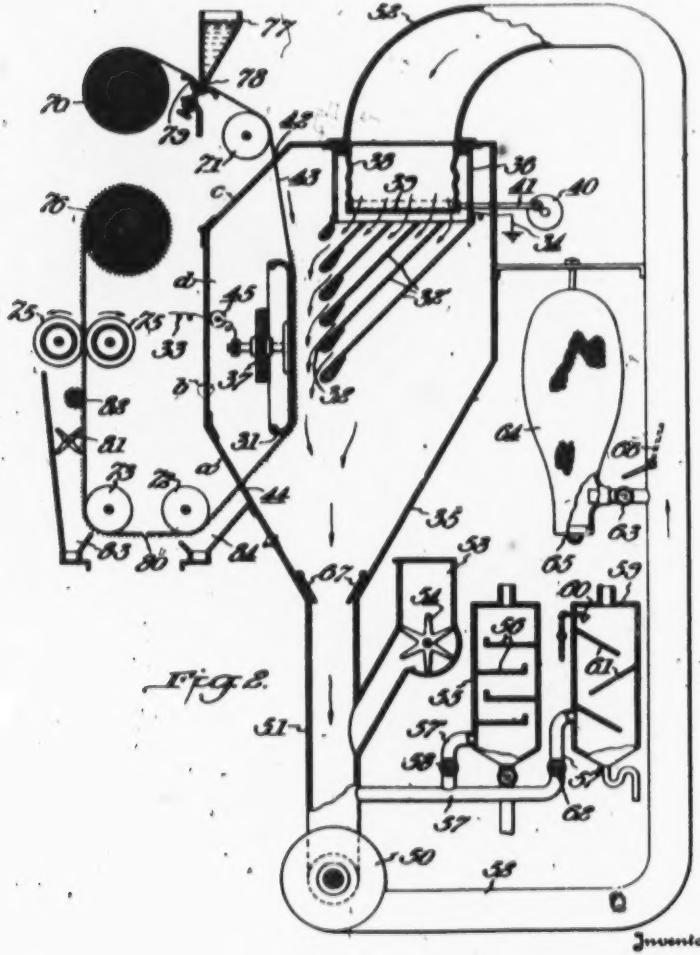

Fig. 2.

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[fol. 682]

Sept. 12, 1939. H. A. WINTERMUTE 2,173,032

PRODUCTION OF FILE SURFACED MATERIALS

Filed Nov. 23, 1933 3 Sheets-Sheet 3

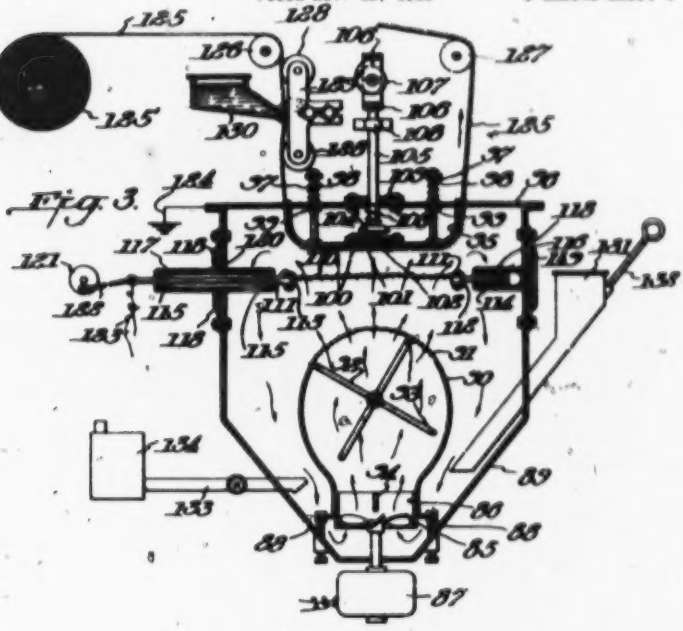

Fig. 3.

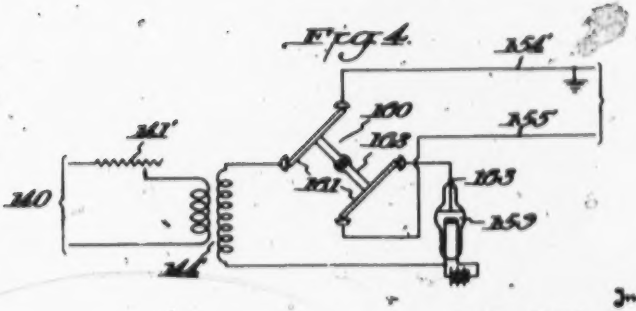

Fig. 4.

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[fol. 683]

Patented Sept. 12, 1939 2,173,032

UNITED STATES PATENT OFFICE

2,173,032

PRODUCTION OF PILE-SURFACED MATERIALS

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Application November 22, 1933, Serial No. 699,456

21 Claims. (Cl. 91—8)

This invention relates to the production of piled surfaces and pile surfaced materials and is particularly directed to apparatus and methods of operation adapted for the efficient production of such surfaces and surfaced materials by a process which involves positioning an adhesive-coated foundation material in an electric field and supplying pile-forming fibers thereto while in said field.

It has been found that the production of piled surfaces by electrically depositing fibers and the like by said process can be advantageously carried out by means of the apparatus and methods of operating which are to be described hereinafter.

Among the novel features and objects of the present invention are included the use of a stream of air or other gas to disentangle the pile forming fibers and to carry them as individual suspended particles into the electric field for deposition on the surface to be piled. Further objects of the invention are to use said stream of gas to prevent or break up the "treeing" of the fibers as they approach the surface to be piled, to return for representation fibers that are not attached when first presented for deposition, to supplement the force of gravity and the electrical forces available in moving the fibers towards the surface to be piled and to provide methods of controlling the relative humidity and other gas conditions within the apparatus in which the pile forming operations are carried on.

Other objects comprise the use of auxiliary electrodes to provide efficient, safe, and convenient control of the electrical forces and the use of special electrical circuits to prevent undesirable treeing and massing of the fibers and to provide advantageous conditions as will be hereinafter described.

The method of pile construction to which the present invention applies comprises, broadly, establishing an electric field of appreciable strength, for example, having a voltage drop of 45,000 volts between two relatively flat, parallel, electrodes three inches apart; placing a base material, e. g. cloth or paper, coated with an adhesive, within the electric field (preferably parallel and adjacent to one boundary of said field); and supplying pile-forming fibers to the region of the electric field. The fibers, initially carrying electric charges or becoming electrically charged by induction, move under the influence of the electric field and contact with the adhesive in oriented position, i. e. perpendicular to the base, whereby only one end of each fiber is attached to the base.

The manner in which these and other objects of the invention are realized will be described in what follows, reference being had for the purpose of illustration to the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a system comprising apparatus shown in sectional elevation and an electric circuit, which embodies certain principles of the invention;

Fig. 2 illustrates a system, shown more or less diagrammatically, but for the most part in sectional elevation, for practicing one embodiment of the invention;

Fig. 3 shows apparatus, in sectional elevation, for practicing the principles of the invention in somewhat different manner; and

Fig. 4 is a diagrammatical representation of a circuit which may be substituted in some cases for the circuit shown in Fig. 1.

Referring to Fig. 1, numeral 5 designates a more or less air tight casing in which are supported two electrodes, 1 and 2, respectively, between which may be set up a strong electric field. A source of energy, to be described later, is connected to electrode 1 by electrical conductor 3 and to electrode 2 by conductor 4, the latter electrode, and casing 5 also, being preferably connected to ground as shown at 6. Electrode 1 is insulated from casing 5 by insulating support 7 and tube 8. Tube 8 functions both as an insulating support and as an inlet bushing for conductor 3. Electrode 2, which is shown as a screen, is supported from the sides of casing 5 by imperforate plate-like members 9, 9. These are free from points or projecting edges, it being desirable that no corona discharge emanate from the apparatus while it is energized.

Above electrode 2 is a basket for sifting the fibers to be used in making piled surfaces. It comprises a screen 10, preferably of closer mesh than that of electrode 2, a reinforcing band 11, and a supporting sleeve 12 of flexible material, i. e. canvas, from which screen 10 depends. Shaking of screen 10 is accomplished by the reciprocal movement of rod 13 brought about in turn by the turning of cam 14 by means not shown. In this embodiment of the invention, screen 10 and connected parts are connected to ground by conductor 15.

The fibers are carried into the region of the electric field, that is, betwe electrodes 1 and 2, by air flotation; fan 16, conn ted to the bottom and top of casing 5 by flues and 18, respec-

[fol. 684]

tively, being used to move the air through the apparatus. The fibers, which may be flocks cut from rayon or other fibrous material, are fed into the apparatus from hopper 19 in amounts regulatable by damper 20. As the fiber inlet is on the inlet side of fan 16 the pressures within the system may be readily regulated by means of dampers 21 and 22 so that the pressure within hopper 19 is slightly below atmospheric thus facilitating the movement of the fibers from the hopper into the air stream passing in flue 17.

The manner in which the apparatus is operated in constructing piled surfaces is set forth in the following description. The material to be piled, say a sheet of paper, is coated with adhesive and placed upon electrode 1 with the adhesive facing upwards, as shown at 23. The electrodes are now energized, the circuit indicated, to be later described, being used for that purpose. Fan 16 is started and fibers are added from the hopper 19 to the air passing in flue 17. Many fibers come from storage rather densely packed together and disintegration is necessary before they can be introduced into the electric field for deposition on material 23. The agitation provided by the fan and by passage through the flues is sometimes sufficient to break up the masses of tangled fibers, but it has been found advantageous to supplement this action by further agitation on screen 18. Some of the fibers brought to screen 18 by the air stream passing in flue 18 immediately pass through screen 18 and electrode 2 and are deposited by action of the electric field existing between electrodes 1 and 2 upon the adhesive covered material 23. Some of the fibers reach screen 18 in clumps, however, and pass through only after they have been agitated upon the surface of the screen and blown with the passing air current.

In this particular embodiment of the invention the force of gravity and the kinetic energy furnished by the air stream both augment the electric forces in pushing or pulling the fibers down upon the surface of sheet 23. The air stream must turn at 90 degrees, however, as it approaches the surface of sheet 23 in order to pass around electrode 1, as indicated by the arrows, and enter flue 17 beneath it; but this seems to be more beneficial than otherwise. The fibers that have been properly separated, charged and oriented are pulled down, definitely, to the surface and adhere to it because of the predominance of the electric forces over any sidewise pull set up by the air stream. The fibers which tree or settle in knob masses over the surface of the pile are blown away by the air and carried into flue 17 to be again introduced, after further disintegration, for deposition. As pointed out above, the screen comprising electrode 2 is of coarser mesh than screen 18; for example, the former may have 4 openings to the linear inch while the latter may have 8 or more. This is to assure the ready passage of fibers through electrode 2. But sometimes long and rough fibers will build up on screen 2, necessitating the shaking or brushing of this electrode. It is to advantage to keep electrode 2 free from complications and auxiliary members and in careful alignment, parallel to electrode 1. This is best accomplished by supporting it as shown, but where shaking and the like must be resorted to, electrode 2 may be eliminated and the bottom surface of screen 18 can be made to function as the top boundary of the electric field.

Fig. 3 illustrates apparatus in which the surface to be piled is held in vertical position. This construction has been found to have advantages when the fibers tend to tree between the electrodes and/or become grouped in unattached masses over the uncompleted pile. Unattached fibers can be more positively blown from a vertical surface than from horizontal surfaces such as that shown in Fig. 1. The construction illustrated in Fig. 2 also makes possible the piling of surfaces while they are moving and permits of humidity control within the apparatus.

In Fig. 2, numeral 31 designates the electrode over which material 42, which may be a flexible sheet of fabric, is caused to pass while a pile is built upon the surface thereof. Electrode 31 is maintained, preferably, at high potential and is supported by insulating means as indicated by member 37. Electrode 31 is opposed by electrode 32, made up of members 32' extending transversely and, in general, parallel to the surface of electrode 31. Members 32' are positioned from one-half to one and one-half inches apart, depending upon electrical conditions, the velocity of the air passing, and other conditions. The lower edges of members 32', the edges nearest to electrode 31, are bent back or otherwise rounded to prevent corona discharge therefrom. With the edges thus rounded and spaced and carefully aligned so as to be at an equal distance from the surface of electrode 31, members 32' comprise a boundary for any electric field established between electrodes 31 and 32 that is not essentially different in its characteristics from that to be had with a flat plate. Electrode members 32' are supported, by means not shown, so their upper edges are in alignment with the bottom, and open end, of wind box 36; and air leaving the wind box is directed, in an oblique direction, by members 32' towards the surface of electrode 31. Within wind box 36 is a fiber sifting device made up of flexible sleeve 38, screen 39 dependent therefrom, and an agitating device indicated by crank 40 and connecting rod 41.

The electrodes and supports just described are enclosed in a chamber or casing 35. Casing 35 is preferably substantially air tight, but as it is difficult, although not impossible, to handle material 42 within the casing, slots are made at 42 and 44 for the entrance and exit of the material. Casing 35 is ordinarily made of electric conducting material, grounded by conductor 34, but it is advisable in some cases to make it of non-conducting material, especially that part enclosing high potential electrode 31 as indicated at a, b, c and d. Side b can be built as a door through which electrode 31 can be inspected and positioned and the insulation thereabouts can be cleaned. Electric conductor 33 connects electrode 31 to energizing means outside the casing, such as that indicated in Figs. 1 and 4. It is held in insulated relationship with wall d of casing 35 by bushing 43.

Air, or any suitable gas, is circulated through casing 35 by fan 50, connections to the fan being made by flues 51 and 52. Fibers are added to the air stream through hopper 53, the amounts added being controlled by measuring wheel 54. The characteristics of the circulating air, especially as regards humidity conditions, are controlled by adding conditioned air and releasing surplus air. Air drier than that of the atmosphere can be obtained by drawing air through drying chamber 55 which is connected to flue 51 by flues 57 and 57', control being secured by valve 58. Dehydration of the air is brought about by spreading cal-

cium chloride over trays 96 and causing the air to pass over the chloride. The air in the system may be too dry in cold weather. Humidification can be secured by drawing air into the system through spray chamber 89, water provided by spray 90 being evaporated as the air passes over baffles 91. Valve 92 permits close regulation of the humidified air admitted. Conditioned air admitted for humidity correction replaces air already in the system and this is released through valve 93. The released air carries fibers in common with the other air in circulation and these are collected in bag filter 94, removed through closure 95, and returned to hopper 86. It has been found advantageous to so regulate valves 83 and 93 (or 92) and dampers 96 and 97 that the pressure in casing 26 is held at or very slightly above atmospheric pressure. If the pressure is slightly above that of the atmosphere, air passes out slots 62 and 64, whereas at lower pressures it would enter through them. Of course, by suitable control means, gases for special purposes can be introduced into the system. If the adhesive on material 45 is accompanied by solvents having vapors which may form explosive mixtures with air, such mixtures can be avoided by adding carbon dioxide or other non-supporter of combustion in appreciable quantity. While ordinarily sparks are not present in the apparatus, improper control may cause the inadvertent presence of sparks and explosive mixtures of air and vapors are to be avoided.

The material upon the surface of which a pile is to be constructed may be a fabric ordinarily supplied in roll form as indicated by roll 70. It is stretched over guide rolls 71, 72 and 73 and over electrode 31 and slowly moved by suitable means such as rolls 78, 79 which have raised and corrugated bands at the ends thereof to grasp the sheet 45 at the edges and draw it over the other rolls and permit it to be re-rolled as indicated at roll 70. The adhesive may be put on by various methods. The method illustrated consists of the use of trough 77 with spreading edge 78 which presses upon or projects towards the fabric as it is stretched over adjustable member 79. The fibers are attached, in positions perpendicular to the surface of the fabric, for the most part, as the fabric moves over electrode 31. The piled material is then finished as may be necessary or desired. Driers and/or vulcanizers, not shown, may be provided at location 80. A beater 81 and brush 82 remove non-attached or poorly attached fibers after the adhesive has become dry. Hoppers 83 and 84 collect loose fibers that may otherwise become scattered about the operating room.

In operating the apparatus shown in Fig. 2 it is important that the fibers be separately floated in the air stream and be conducted into the electric field in this condition for deposition on the surface to be piled. The aggregates of fibers introduced through hopper 86 are broken up to a considerable extent by fan 88 which includes a wheel with paddles of simple type that is made to revolve at relatively high speed. Further disintegration is obtained with sifting screen 89 operating in the passing air stream. The air stream and burden of suspended fibers, after passing through screen 89, is divided and deflected by members 26' and is made to enter the electric field between electrodes 31 and 32 at an acute angle with the surface of material 45. The individual fibers move across the electric field too rapidly to be followed with the eye, but the result is easily ascertained. Many of the fibers reach the adhesive covered surface in oriented position; that is, perpendicular to the surface, and become fastened at one end to that surface. Some of the fibers approach the surface adverse for lack of sufficient electric charge or some other reason, or become attracted to other fibers and tend to "tree" between the electrodes. If these unattached fibers remain over the uncompleted pile, further deposition of oriented fibers ceases; but by controlling the velocity of the air stream, a removal of such fibers is realized and deposition of fibers continues until they are so thickly packed upon the surface of the material that the material is completely hidden and a pile of appreciable mechanical stiffness results. The air velocity required to blow off unattached fibers need not be high. If blower 88 provides pressure of from one to four inches of water it is satisfactory. Too high a velocity of air in the electric field will move the charged fibers in a different direction from the direction the electric field tends to move them. But it can be readily appreciated that a stream of air moving at a properly chosen velocity and preferably at an angle which causes the air stream to augment the force of gravity will keep the region of the electric field free of uncharged and neutral fibers and permit the separated and charged fibers to be deposited individually into the pile.

The control of humidity has been mentioned above. The fibers commonly used in making piles, for example, fibers of rayon, silk, and cotton and animal hairs such as those comprising wool and rabbit fur, are of small diameter and have great surface area as compared with their mass. They are, therefore, quickly and positively influenced by the moisture content of the medium in which they are suspended. The conductivity, at least the surface conductivity, of the fibers is increased by the sorbed moisture and this alters the rate of distribution of the charges upon the fibers and the manner in which they are moved and oriented in the electric field. It has been found that when the relative humidity of the air carrying the fibers is below 60 percent the fibers are noticeably slower in depositing and forming a pile. A relative humidity above 80 percent, on the other hand, tends to cause rapid deposition, but not in an orderly manner, treeing and undesirable massing of the fibers result. With the means illustrated broadly in Fig. 2 and described above, the air can readily be maintained with humidity values between 65 and 75 percent of saturation, a humidity range in which deposition is quite satisfactory.

In the embodiment of the invention shown in Fig. 3, the fibers are suspended in an air stream, projected upwards into an electric field, further moved upwards by action of the electric field, and deposited on an adhesive covered surface. Fan 88 for moving the air is rotated by motor 97 within a short tube 98 which is supported by adjustable members 99, 99, within casing 99. Supported upon and above tube 98 is a head 99 with a top 91 of metal screen or other suitable open mesh material. Within head 99 is a scraping mechanism 92 comprising a plurality of contact members 93 which, upon rotation of mechanism 92, by means preferably outside casing 99 and not shown, pass in rubbing contact over the inner surface of screen 91. A transverse plate 94 within tube 98 is for the purpose of preventing rotation of the air stream leaving tube 98.

An electrode 95 is suspended from cover 96

of casing 96 by members 97 which are mounted on springs 98. Electrode 95 can be moved downwards if sufficient force is exerted upon it to overcome springs 98, but it cannot move upwards because of stops 99. An anvil 100 with a transversely extending slot 101 is mounted on electrode 95. Within slot 101 is rapping member 102 which is dependent from rod 103 which is in turn dependent from yoke 104 which rides on cam 107. Rod 105 is vertically moveable in bearings 108 and 109 and when yoke 106 drops off the high point of cam 107, spring 110 causes hammer member 104, which is positively attached to rod 105, to strike strongly upon anvil 100 and suddenly move and vibrate electrode 95.

An electric field for the depositing of fibers can be established between screen 91 and electrode 95 if either of these members is properly insulated. But it has been found more convenient and more efficient and in general safer to introduce an intermediate member 110 between the members mentioned. Member 110 is shown as a screen, preferably of one-quarter inch or coarser mesh, although closer mesh can be used if the screen is effectively shaken. Screen 110 is bounded by a rounded band 111 and this is supported by a plurality of members 112 and 113 which can reciprocate in bearings 114 and 115 within insulating supports 116 and 117, respectively. The insulators 116 and 117 are fastened by clamping members 118 as shown over bars 119 and 120, respectively, in the walls of ch 4 95. Member 113 passes completely through member 111 and so functions as an inlet conductor for electric current supplied through conductor 122 and as a connection to the agitating mechanism designated by numeral 121. A connecting link 123 of insulating material is inserted between member 113 and agitating mechanism 121 so the latter may be maintained at ground potential.

The apparatus shown in Fig. 2 is commonly used to build piles upon the surfaces of paper and textile fabrics. Roll 125 indicates a supply of cloth that is guided by rolls 126 and 127 to and from the under surface of electrode 95. Rolls 128, 129, in adjustable carriage 130, position travelling cloth sheet 126 so it is coated with adhesive from a spreading device 131 similar to those used in coating so-called oil cloth. The fibers or other pile forming elements are introduced into the apparatus through supply bin 131, a plunger with handle 133 being used to force the fibers downwards when necessary. Air, or gases for conditioning the air or other gaseous medium within the apparatus, can be brought in through pipe 134 from any suitable supply as indicated by chamber 135.

In operating the apparatus shown in Fig. 2, the high potential side of a source of unidirectional current is connected to conductor 122, the other side being connected to conductor 124 and to ground. The devices, not shown, for drawing sheet 126 through the apparatus, are set in motion and adhesive is applied to said sheet by spreader 131. Motor 97 is started and fibers are fed into the air current set up by fan 98. Scraper 92 is made to rotate. The volume and velocity of air passing through screen 91 is regulated by altering the speed of motor 97 and by altering the air inlet to the fan by raising or lowering sleeve 93 with adjustable supports 94, 95. It should be pointed out that when the fibers are easily disentangled and separated by the fan, screen 91 and scraper 92 are not needed and can be removed, a funnel a few inches high on top of sleeve 93 being then used to direct the fibers towards the electrodes above.

Adjustments in the position of screen electrode 110 can be made through clamps 118, but in general the position of electrode 110 is definitely fixed at from two and one-half to three and one-half inches below, and parallel to, electrode 95. Changes in the strength of the electric field can be made by controlling the electric circuit conditions. The voltage difference impressed between the electrodes, as described, is from 20,000 to 50,000 volts and the screen electrode 110 is ordinarily made negative except where it is advisable to alternate the polarity of the field.

As the fibers begin to deposit on sheet 126, the means, not shown, for rotating cam 107 is set in motion to turn cam 107 at from 20 to 60 R. P. M. This causes sheet 126 to be rapped rigorously by member 102 where it passes under slot 101 and imparts a more gentle vibration to all of that portion of sheet 126 which is held against the under side of electrode 95. Any fibers not attached to sheet 126 by the adhesive are thus forced away from the pile to be redeveloped. In the use of this construction and with this method of operation it is an easy matter to cause the unattached fibers to leave the pile because the forces of gravity pulls directly away from the pile surface and the horizontal components of the air stream forces sweep the fibers along, to the sides of the apparatus, down which they are carried to the fan inlet.

It is an important object in the present invention to energize the electrodes comprised in the apparatus described above in effective manner. An electric circuit for such purpose is diagrammatically illustrated in Fig. 1. A low voltage alternating current source 140, say at 220 volts and 60 cycles, is connected through a voltage control rheostance 141 and a double throw reversing switch 142 to a step up transformer 144. The high potential terminals of the transformer are connected to stationary shoes 145 and 146, respectively, of mechanical rectifying switch 147. The switch is turned by synchronous motor 148 in synchronism with the supply current, with the result that stationary shoes 145 and 146 of the rectifier are at reps connected to the high potential current supply at constant polarity, that is, one shoe is always positive and the other is always negative. Shoe 145 is shown connected through conductor 150 and dampening or loading resistance 151 and shunting switch 152 to ground 6 and the grounded parts of the pile forming apparatus through conductors 4 and 16. Shoe 146 is shown connected to insulated electrode 1 through conductors 153 and 3. Fibers can be most effectively charged, oriented, and deposited with an electric field of constant polarity and a direct or rectified current source is preferably utilized, therefore, in energizing the electrodes. But it has been discovered that, in the use of a constantly applied electric field, certain undesirable conditions become emphasized. Tufting of fibers, once begun, tends to continue and makes it necessary to operate the scouring air streams and rapping devices with great diligence. Also with a constantly applied potential a sheet of insulating material being piled becomes very strongly attracted to the electrode over which it is passing. It has been found that these tendencies can be checked if the polarity of the electric field is occasionally reversed. This is done in the circuit of Fig. 1, for example, by operating reversing switch 142 with an automatic device,

not shown, that causes the grounded side of the circuit, connected to shoe 188, to be alternately negative, for example, for two to five seconds and then positive for one-half to two seconds. The high voltage electrode 1 is at opposite polarity to that of electrode 2 during the same periods, of course.

Very rapid reversals, in synchronism with the alternating current source, have been found advantageous at times. This condition is obtained by shifting rectifier 167 with relation to the revolving field of synchronous motor 166 by clamping adjustable coupling 151 in a different circumferential position. In this manner electrode 1 can be maintained, say, positive and at high potential, for most of the half cycle and negative and at lower voltage for a short part of the cycle. In other words, through what might be called a poor setting of the rectifier, rectification is not complete and a short energization at opposite polarity follows or precedes each half wave of given polarity. "Stoss" or steep wave front impulses have also been used with good effect in some depositions. This condition is obtained by opening switch 183 and inserting a condenser 187 and a spark gap 186 into the circuit as shown. The Stoss circuit will be more effective if a load 188 requiring considerable current is placed across leads 184 and 185.

Vacuum tube or hot cathode rectifiers can be used instead of a mechanical rectifier. Fig. 4 shows the use of a single hot cathode rectifier 190 which will permit half wave energization at constant polarity. To effect reversal of polarity with this type of rectifier in the circuit, the reversing means must be placed on the high potential side of the transformer as illustrated by the use of switch 180. Switch 180, made up of conducting members 181 supported by insulating member 182, will, upon rotation or upon oscillation through 90 mechanical degrees, alternately connect terminal 183 of rectifier 190, which is always negative, with high potential lead 185 and with ground. In oscillating switch 180, a longer pause is made at one set of connections than at the other, thus permitting energization at one polarity for longer periods than at the other polarity. This asymmetrical timing of polarity reversals is not necessary, but has been found advantageous in connection with the present invention.

The apparatus and methods described above have been found to be particularly advantageous in handling pile-forming fibers of relatively great length, for example, from ⅛ to ¼ inch in length and longer.

I claim:

1. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrode means insulated from each other, one of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

2. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising superposed electrode means insulated from each other, one of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

3. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising superposed electrode means insulated from each other, the upper of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

4. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising superposed electrode means insulated from each other, the lower of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

5. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrodes insulated from one another, means for establishing an electric field between said electrodes, means for passing a web of foundation material through said field adjacent one of said electrodes, means constituting a conduit for directing a gas stream between said electrodes, means for imparting motion to the gas stream in said conduit, means for introducing pile forming material into said gas stream and means in said conduit for breaking up clumps of the pile forming material.

6. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising superposed electrode means insulated from each other, the lower of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for agitating the foraminous electrode, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

7. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrode means insulated from each other, one of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for passing a web of foundation material through said electric field adjacent the electrode opposing the foraminous electrode, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, and means for introducing pile forming material into said gas stream.

8. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending masses of pile forming materials in a gas stream, disintegrating said masses of pile forming material in said gas stream, and directing the gas stream containing the suspended material into the region of the electric field.

9. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending masses of pile forming materials in a gas stream, disin-

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tegrating said masses of pile forming materials by passing said gas stream through a foraminous member, and directing the gas stream containing the suspended material into the region of the electric field.

10. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending masses of pile forming materials in a gas stream, disintegrating said masses of pile forming materials by passing said gas stream through a foraminous member while agitating the foraminous member, and directing the gas stream containing the suspended material into the region of the electric field.

11. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending pile forming materials in a gas stream, directing the gas stream containing the suspended material into the region of the electric field, and periodically alternating the polarity of the electric field with periods of constant polarity of at least about one-half second.

12. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending pile forming materials in a gas stream, directing the gas stream containing the suspended material into the region of the electric field, and periodically alternating the polarity of the electric field with a period substantially greater than that of commercial alternating current.

13. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending pile forming materials in a gas stream, and directing the gas stream containing the suspended material through one of said electrode structures into the region of the electric field while agitating the electrode through which the gas stream passes.

14. A method of forming pile-surfaced materials, which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, suspending pile forming materials in a gas stream, directing the gas stream containing the suspended material through one of said electrode structures into the region of the electric field while agitating the electrode through which the gas stream passes, and periodically alternating the polarity of the electric field with periods of constant polarity of at least about one-half second.

15. In the production of piled surfaces by passing a stream of gas containing pile forming material adjacent an adhesive-surfaced foundation material positioned in an electric field, the step comprising adding a conditioning medium to the stream of gas whereby the conductivity of the pile forming material is altered.

16. In the production of piled surfaces by passing a stream of gas containing pile forming material adjacent an adhesive-surfaced foundation material positioned in an electric field, the step comprising regulating the humidity of the gas stream to a predetermined degree.

17. In the production of piled surfaces by passing a stream of gas containing pile forming material adjacent an adhesive-surfaced foundation material positioned in an electric field, the step comprising adding gaseous medium of predetermined humidity to said gas stream.

18. In the production of pile surfaces by passing a stream of gas containing pile forming material adjacent an adhesive-surfaced foundation material positioned in an electric field, the step comprising maintaining the humidity of the gas stream at a predetermined degree between about 40 percent and about 90 percent relative humidity.

19. A method of forming piled surfaced materials, comprising establishing an electric field between opposed electrode structures, bringing pile forming fibers into said electric field adjacent an adhesive-surfaced foundation material, and controlling the electrical deposition of the fibers by controlling the surface conductivity of the fibers.

20. In the production of piled surfaces by passing a stream of gas containing electrically charged pile forming material adjacent an adhesive-surfaced foundation material positioned in an electric field, the step comprising regulating the humidity of the gas stream to a predetermined degree.

21. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrode means insulated from each other, one of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, means for introducing pile forming material into said gas stream, said foraminous electrode having openings adapted to break clumps of said pile forming material into individual fibers.

22. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrode means insulated from each other, one of said electrodes being foraminous, means for establishing an electric field between said electrodes, means for establishing a gas stream through said foraminous electrode and into the electric field between said electrodes, means for introducing pile forming material into said gas stream, and means cooperating with said foraminous electrode for breaking clumps of said pile forming material into individual fibers.

23. Apparatus for forming a pile upon a surface by affixing attenuated materials thereto comprising opposed electrodes insulated from one another, means for establishing an electric field between said electrodes, means constituting a conduit for directing a gas stream between said electrodes, means for imparting motion to the gas stream in said conduit, means for introducing pile forming material into said gas stream and beating means in said conduit for breaking up clumps of the pile forming material.

24. A method of forming pile-surfaced materials which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, bringing pile-forming fibers into the electric field and periodically alternating the polarity of the electric field with periods of constant polarity of at least about one-half second.

25. A method of forming pile-surfaced materials, comprising establishing an electric field be-

tween opposed electrode structures, bringing pile-forming fibers into said electric field adjacent an adhesive-surfaced foundation material, and controlling the electrical deposition of the fibers by controlling the conductivity of the fibers.

26. A method of forming pile-surfaced material, comprising establishing an electric field between opposed electrode structures, bringing pile-forming fibers into said electric field adjacent an adhesive-surfaced foundation material, and controlling the electrical deposition of the fibers by controlling the moisture content of the fibers.

27. A method of forming pile-surfaced materials which comprises establishing an electric field between opposed electrode structures, positioning an adhesive-surfaced foundation material between said electrodes, bringing pile-forming fibers into the electric field and periodically alternating the polarity of the electric field with potentials of substantially different voltage in periods of alternate polarity.

28. A method of forming pile-surfaced material which comprises establishing an electric field of periodically alternating polarity, positioning an adhesive-surfaced foundation material in said field and bringing comminuted fibrous material into the field in condition to be deposited thereon, thereby to produce a uniform pile surface having the fibers oriented in endwise position on the adhesive surfaced material.

29. In the production of pile-surfaced material, the method which comprises feeding along a predetermined path an adhesive-coated foundation material creating an electrostatic field of alternating polarity intersecting said path and feeding comminuted fibrous material into said field in condition to be deposited thereby to produce a uniform pile surface having the fibers oriented in endwise position on the adhesive surface on the foundation material in said field.

30. Apparatus for forming pile-surfaced material comprising means for establishing an electric field of periodically alternating polarity, means for continuously introducing into said field adhesive-surfaced foundation material and means for introducing pile-forming fibers into said field.

31. Apparatus for forming pile-surfaced material comprising means for feeding along a predetermined path a foundation material, means for coating the foundation material with adhesive, means for creating an electric field of alternating potential intersecting said path and means for introducing pile-forming fibers into said field.

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Sept. 12, 1939. A. F. MESTON 2,173,078

PRODUCTION OF PILE SURFACES

Filed Oct. 4, 1933 2 Sheets-Sheet 1

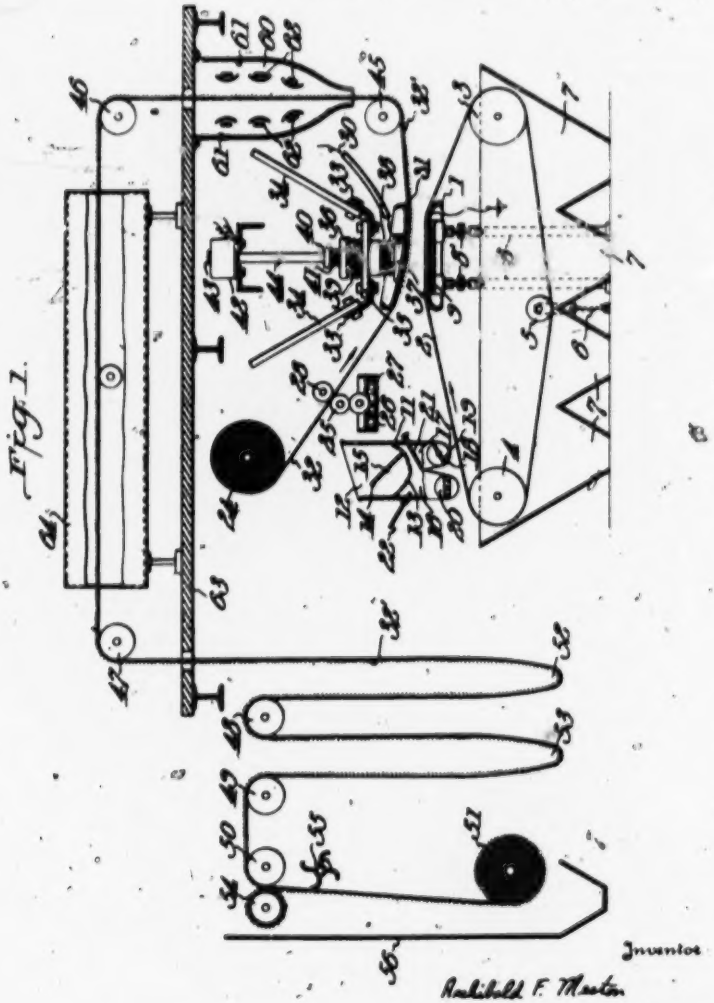

Fig. 1.

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PRODUCTION OF FILE SURFACES

Filed Oct 4, 1933 2 Sheets-Sheet 2

Fig. 2.

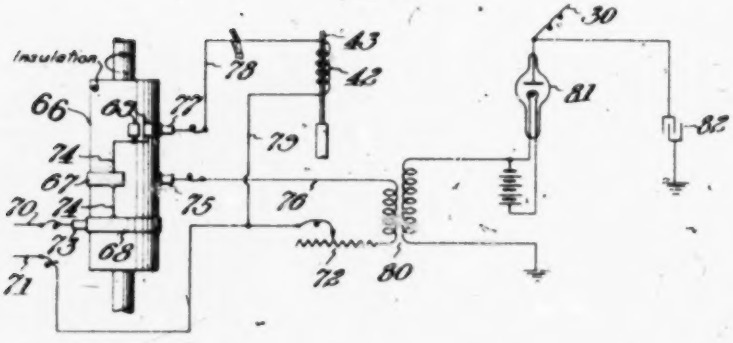
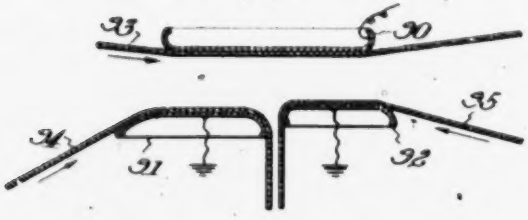


Fig. 3.



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UNITED STATES PATENT OFFICE

2,173,078

PRODUCTION OF PILE SURFACES

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Application October 4, 1933, Serial No. 692,201

24 Claims. (Cl. 91—8)

This invention relates to the production of pile-surfaced materials and is particularly directed to apparatus and methods for operation adapted for the efficient production of such materials involves positioning an adhesive coated foundation material in an electric field and supplying pile-forming fibers thereto while in said field. It has been found that improvements in the effectiveness of the production of pile-surfaced materials by said process may be obtained by the use of novel forms of apparatus and methods of operation which will be more particularly described hereinafter.

Among the novel features and objects of the present invention are included the use of a unidirectional electric field, the provision of electrodes adapted to provide an electric field substantially free of corona discharge, the disposition of the electrodes whereby the surface to be piled is positioned above the pile-forming material so that the material is moved upward against gravity in depositing it on the surface, the provision of means for continuously or intermittently agitating the upper electrode and/or object being coated to effect the removal of surplus pile-forming material and prevention of tossing of the material, the provision of one or more traveling belts or the like for bringing the pile-forming material into the electric field, and the intermittent application of potential between the electrodes, which is advantageous in causing agglomerated or flocculated masses of fibers to break up.

These and other features and objects of the invention will be more particularly described for the purpose of illustration with reference to the accompanying drawings, in which:

Fig. 1 is a diagrammatic sectional elevation of a system of apparatus embodying the principles of the invention;

Fig. 2 is a diagrammatic plan of an electrical circuit adapted for practicing the invention; and

Fig. 3 is a fragmentary section of a modified form of the invention providing a plurality of fiber supplying means.

In Fig. 1 the electric field which causes the deposition of the pile-forming fibers is set up between the two electrodes 1 and 31. These electrodes, as shown, are formed with relatively smooth, flat surfaces and rounded edges in order that a strong field of, for example, 4,000 to 50,000 volts (peak) per inch can be set up between them without the formation of corona discharge. The avoidance of corona discharge results in an improved uniformity of deposition. For purposes of convenience electrode 1 is preferably held at ground potential, while electrode 31, insulated from ground as will be later described, is continuously maintained at, or is intermittently brought to high potential by connecting it to a high potential current source through conductor 30. The electric field set up is unidirectional, the upper electrode preferably being negative with relation to the bottom electrode.

The sheet material 32 upon which the pile is to be formed is shown passing over the bottom surface of electrode 31. Sheet 32 need not actually touch electrode 31, but it is convenient to have it pass across the surface of that electrode with sliding contact, as shown. A belt 2, is used to carry the pile-forming fibers into the electric field. This passes over electrode 1 around pulleys 3 and 4 and under a tightening idler 5 which is held against the inner surface of the belt by springs 6. A driving mechanism, not shown, such as a variable speed motor and reduction gear, turns pulley 3 at a speed which moves the belt through the electric field at the desired rate. The speed of travel of the feed belt may be widely varied. Increasing its speed relative to the speed of web 32 increases the heaviness of the pile formed on the latter. Excess material which is not attracted to and deposited upon sheet 32 falls into hoppers 7 to be reused later. Straddling the hoppers are uprights, two of which are shown at the far side at 8, supporting a transverse member 9 upon which electrode 1 rests. Uprights 8 include jackscrews 8' which make possible any desired adjustment of the distance between the electrodes and their relative position.

It is desirable that the pile-forming material, for example rayon flocks, be spread evenly over belt 2 which carries it into the electric field. Belt 2 is preferably an electrical conductor but it may be of canvas or other poorly conducting material. It passes under apparatus 11 consisting of a supply hopper 12 with a bottom of wire screen 13 of relatively coarse mesh and with a scraping device 14 which revolves around rod 15, scraping screen 13 twice in each revolution, and two dependent smaller hoppers 16 and 17, each of which has a screen bottom and an agitator or scraper. Hopper 17 is shown with end cover removed to illustrate the construction, the screen being indicated at 18 and the scraper at 19. Ordinarily a cover is over the end of hopper 17 similar to that shown at 20 which covers the end of hopper 16. Sliding plates 21 and 22 permit the closing of hopper 16 or 17, respectively,

when there is need for removing an end cover to remove unreasonable masses of material that have collected. In operation hopper 12 is filled evenly from end to end with pile-forming material. Scraper 14 is turned either manually or by a power device so that the material is scraped through 13 in semi-broken up condition and falls into hoppers 16 and 17. Scraper 19 in hopper 17 and a similar scraper in hopper 16 work the material through the fine screens in the bottom of these hoppers and it is disseminated evenly over moving belt 2.

The sheet to be coated is usually supplied in a roll as shown at 24. This roll is suspended in an elevated position so that the sheet, before entering the electric field between electrodes 1 and 31, can be coated with adhesive by such apparatus as that shown, comprising an applying roll 26 which is coated with adhesive by a supply roll 26 which is rotated partly submerged in liquid or semi-liquid adhesive in trough 27. Other suitable means may be used for coating the surface of the sheet, but the above has been found very satisfactory for several common types of adhesive. A roll 28 assists in supporting sheet 22 as adhesive applying roll 26 presses against it.

Electrode 31 is supported at one or more points depending upon its width. When treating material 2 to 3 feet wide two supports are ordinarily necessary. These supports depend from angles 33 which extend transversely to but above sheet 22. The angles in turn depend from insulating means 34 which may be rods or bars of Bakelite composition or other insulating material having appreciable tensile strength. The support itself consists of a flange or yoke 35 in which there is suspended a member 36 which in turn is fastened to boss 37 attached to the back surface of electrode 31. Springs 38 and 39 hold member 36 in a yielding position within flange 35. A hole extends part way through member 36 and inserted into this hole to within say ¼" of the bottom thereof is a member 40 which is utilized as a hammer when it is desirable to shake or vibrate 31. Spring 41 is of such length and stiffness that it supports the weight of member 40 and keeps it from resting on the bottom of the hole within member 36. Hammer 40 is operated by a solenoid 42 which, when energized, pulls down on core 43 which in turn pushes down on insulating rod 44 compressing spring 41 and causing the bottom of hammer member 40 to strike the bottom of the hole within 36.

Sheet 22, after being drawn between the electrodes and having a pile deposited on it, passes as 22' over rolls 45, 46, 47, 48, 49 and 50 and is rolled upon mandrel 51 or is otherwise disposed of. Some or all of these rolls are mechanically rotated. By using appropriate controls known to the arts, but not shown in the figure, the rotating means can be operated interdependently with the result that the sheet is kept taut where desired and caused to sag, as at 52, 53, where desired. Between roll 49 and mandrel 51 are positioned the auxiliary means for drying and combing the piled sheet. The specifications and arrangement of the necessary equipment will vary with the adhesive used and other factors. In short cases a dryer immediately follows the depositing means and this may take the form of a chamber 60 with inner walls 61 comprising radiating surfaces which receive and reflect heat furnished by electric resistance units 62. If valuable solvents are evaporated from the adhesive while the sheet is passing through chamber 60, suitable condensing or absorbing equipment can be provided to collect them, but ordinarily the vapors evolved are conducted to atmosphere by simple ventilating means. If the adhesive is of the nature of rubber latex it is desirable to vulcanise it after drying. Apparatus suitable for this purpose can be placed on a platform 63 above the depositing apparatus, as indicated by numeral 64. After cooling, provided by movement through loops 52, 53, the pile is combed or brushed by means of 54, the loose fibers are shaken off by rotating rapping device 56, and any other finishing operations, not indicated, such as shearing, are performed. In rolling or folding the finished product care is taken to not damage the pile, and to this end spacing strips are inserted and other precautions known to the velvet trade are taken.

Electrodes 1 and 31 may be flat and parallel, but advantages have been found in so shaping and positioning the electrodes that they are farther apart at the side where the pile material enters than on the opposite side. This causes the fabric being formed to be subjected to a progressively stronger field as it passes along and is being built up with additional fibers. A very strong field in the initial stage of deposition is more apt to cause the fibers to flatten against the adhesive or the sheet than is a weak field; while a strong field at the final stage of deposition is advantageous in that it forces additional fibers down into an already built up pile.

Certain difficulties in operation may be encountered when a strong electric field exists constantly between electrodes 1 and 31. Some of the fibers mat together and others string out or "tree" between the electrodes if the field is maintained continuously, and the desired result of keeping the fibers in parallel arrangement and projecting one end of each fiber into the adhesive may not be obtained. It has been found advantageous to lower the potential at which the upper electrode is held, or to reduce it to ground potential intermittently, for example, every few seconds. While the electric field is weak, the upper electrode is advantageously vibrated or shaken to remove unattached or loosely held fibers. A satisfactory cycle consists of from two to ten seconds with a strong field and one to three seconds with a weak field or no field at all. An electric circuit for furnishing such conditions is shown in Fig. 2.

Fig. 2 illustrates an electric circuit and control which may be used in energizing the apparatus shown in Fig. 1. Alternating current at low potential (110 or 220 volts) is supplied through leads 70 and 71. Lead 71 is connected through a voltage control resistance 72 to one end of the low voltage winding of step up transformer 68. It is also connected through a shunt lead 73 to one end of solenoid 42. Lead 70 contacts through brush 73 with a slip ring 66 on drum 65. Connected to ring 66 by conductor 74 are other rings or surfaces 67 and 69 for making contact with brush 75 and brush 77 which connect through leads 76 and 78, respectively, to transformer 69 and solenoid 42. When drum 65 is rotated, transformer 69 is intermittently energized as is solenoid 42. It is not difficult to arrange the contacts on drum 65 and rotate it at such speed that transformer 69 is energized for say four seconds and then de-energized for one second while solenoid 42 is being intermittently energized to rap electrode 31 two or more times.

A steady pull on the fibers while they are being deposited or attached is desirable and the energy impulses set up by transformer 69 are rectified by

[fol. 694]

any practical means before they reach electrode 31. A Lemp type mechanical rectifying switch has given satisfactory results, but in Fig. 2 a hot cathode type of rectifying tube 81 is shown for this purpose. It is known that two tubes with a double winding on the transformer or four tubes properly connected will permit the use of both sides of the voltage wave, but tests have shown that satisfactory results can be obtained with one tube through which one side only of the voltage wave passes if electrode 31 is well insulated. Electrodes 1 and 31 and the air between make up a condenser which tends to even out the current supply, and rectifying tube 81 prevents any of the current from returning to the transformer and so reducing the voltage impressed across the electrodes. Where it is desirable to reduce the voltage across the electrodes frequently, say by grounding electrode 31, the disposal of a high capacity charge is an inconvenience and in such cases condenser 82 is not provided. Instead, a grounding switch actuated by, or, at least, in synchronism with, drum 66 is connected to line 30.

Fig. 3 illustrates a modification of the invention whereby the pile-forming fibers may be supplied in two separate successive portions. Electrode 96 and web 93 correspond to electrode 31 and web 32, respectively, of Fig. 1. The corresponding lower electrode 1 of Fig. 1 is represented in Fig. 3 by two separate electrodes 91 and 92, each cooperating with separate supply belts 94 and 95 to supply pile-forming materials in successive portions. When desirable one of the belts may be positioned to supply the fibers with closer spacing to the surface to be coated than to the other. Through the greater flexibility of operation made possible by the modification of the invention shown in Fig. 3 it is possible to obtain pile surfaces of increased thickness of pile and uniformity.

Non-uniformity of pile may not be objectionable or may be desirable in some instances and the results obtained from electrodes which have not been carefully shaped and positioned to prevent corona discharge and local highly stressed electric fields may be satisfactory. But carefully conducted experiments made to determine the shape of electrodes best suited for the production of evenly formed piles have shown that distinct advantages reside in those just described.

I claim:

1. Apparatus for the production of pile-surfaced materials comprising a plurality of electrode means, circuit elements connecting said electrode means to provide an electric field therebetween, the opposing faces of said electrode means being free from elements of small radius of curvature, means for positioning an adhesive-coated web of foundation material in said field adjacent one of said electrode means, and means for supplying pile-forming fibers adjacent the other of said electrode means.

2. Apparatus for the production of pile-surfaced materials comprising a plurality of electrode means, circuit elements connecting said electrode means to provide an electric field therebetween, the radii of curvature of the elements of the opposing faces of said electrode means being so large that no corona discharge is developed at potential differences of from 4,000 to 50,000 volts per inch, means for positioning an adhesive-coated web of foundation material in said field adjacent one of said electrode means, and means for supplying pile-forming fibers adjacent the other of said electrode means.

3. Apparatus for the production of pile-surfaced materials comprising a plurality of electrode means, circuit elements connecting said electrode means to provide an electric field therebetween, the opposing faces of said electrode means being positioned at an acute angle to each other, means for positioning an adhesive-coated web of foundation material in said field adjacent one of said electrode means, and means for supplying pile-forming fibers adjacent the other of said electrode means.

4. Apparatus for the production of pile-surfaced materials comprising a plurality of electrode means, circuit elements connecting said electrode means to provide an electric field therebetween, the opposing faces of said electrode means being positioned at an acute angle to each other, means for passing an adhesive-coated web of foundation material through said field adjacent one of said electrode means and in the direction of the apex of the angle formed by the electrode means, and means for supplying pile-forming fibers adjacent the other of said electrode means.

5. Apparatus for the production of pile-surfaced materials comprising superposed electrode means, circuit elements connecting said electrode means to provide an electric field therebetween, the lower of said electrode means comprising a plurality of electrode members positioned at different distances from said upper electrode means, means for positioning an adhesive-coated web of foundation material in said field adjacent the upper electrode means, and means for supplying pile-forming fibers adjacent each of said lower electrode members.

6. In an apparatus for the production of pile-surfaced materials by electrostatic deposition including opposed electrode members, means for impressing an intermittent unidirectional potential across said electrode members.

7. In an apparatus for the production of pile-surfaced materials by electrostatic deposition, opposed electrode members, and electrical connections therebetween including automatic means for impressing a unidirectional potential of intermittently varying strength across said electrode members.

8. In an apparatus for the production of pile-surfaced materials by electrostatic deposition, opposed electrode members, and means associated therewith for agitating one of said electrode members.

9. In an apparatus for the production of pile-surfaced materials by electrostatic deposition including opposed electrode members, means for impressing a unidirectional potential of intermittently varying strength across said electrode members, and means for agitating one of said electrode members during the intervals of decreased potential.

10. In an apparatus for the production of pile-surfaced materials by electrostatic deposition including superposed electrode members, rapping means for agitating the upper of said electrode members.

11. In an apparatus for the production of pile-surfaced materials by electrostatic deposition including superposed electrode members, electrically actuated rapping means for intermittently agitating the upper of said electrode members.

12. A process for the production of pile-surfaced materials which comprises positioning an adhesive-coated web of foundation material between superposed electrodes and adjacent the upper of said electrodes, supplying pile-forming

fibers adjacent the upper surface of the lower of said electrodes, and intermittently impressing a unidirectional electric potential across said electrodes.

13. A process for the production of pile-surfaced materials which comprises positioning an adhesive-coated web of foundation material between superposed electrodes and adjacent the upper of said electrodes, supplying pile-forming fibers adjacent the upper surface of the lower of said electrodes, impressing an electric potential across said electrodes and subjecting said web to agitation.

14. A process for the production of pile-surfaced materials which comprises positioning an adhesive-coated web of foundation material between superposed electrodes and adjacent the upper of said electrodes, supplying pile-forming fibers adjacent the upper surface of the lower of said electrodes, impressing an electric potential across said electrodes and subjecting said web to intermittent agitation.

15. A process for the production of pile-surfaced materials which comprises positioning an adhesive-coated web of foundation material between superposed electrodes and adjacent the upper of said electrodes, supplying pile-forming fibers adjacent the upper surface of the lower of said electrodes, and impressing an electric potential of intermittently varying strength across said electrodes.

16. A process for the production of pile-surfaced materials which comprises positioning an adhesive-coated web of foundation material between superposed electrodes and adjacent the upper of said electrodes, supplying pile-forming fibers adjacent the upper surface of the lower of said electrodes, impressing an electric potential of intermittently varying strength across said electrodes and subjecting said web to agitation in the intervals of decreased potential.

17. In a process for the production of pile-surfaced material, the step comprising establishing an electrical field extending in a substantially vertical direction, coating a surface to be piled with adhesive and positioning in it the upper portion of said electric field with the coated surface directed downwardly, supplying pile-forming elements to the electric field below said surface and jarring from the surface pile-forming elements electrostatically raised to the surface but not firmly attached thereto.

18. Apparatus for forming pile surfaces comprising electrode means insulated from each other, means for establishing an electric field between said electrodes including a source of current and means for converting said current into periodically varying impulses of different electrical characteristics from said current and means for introducing pile-forming material into said electric field.

19. Apparatus for forming pile surfaces comprising electrode means insulated from each other, means for establishing an electric field between said electrodes including a source of alternating current and means for converting said alternating current into periodically varying impulses of different electrical characteristics from said alternating current and means for introducing pile-forming material into said electric field.

20. The method of producing pile-surfaced sheet material which comprises providing an electrical field of intermittently varying strength, positioning an adhesive-surfaced foundation material in said field and supplying pile-surface forming fibers to said field.

21. The method of producing pile-surfaced sheet material which comprises providing an electrical field of intermittently varying strength, passing an adhesive-surfaced foundation material through said field and supplying pile-surface-forming fibers to said field.

22. A process for the production of pile-surfaced materials which comprises establishing an electrical field between spaced electrodes, conducting an adhesive-coated web of foundation material betwen said electrodes, supplying to said field pile-forming fibers of a character which tend to tree therein, while impressing an electrical potential across the electrodes, and subjecting the web to agitation as it is conducted through the field, whereby treeing is minimized.

23. In an apparatus for the production of pile-surfaced material by electrostatic deposition, opposed electrode members, means for establishing an electrical field between said members, means for positioning an adhesive-coated web of foundation material between said electrode members, means for supplying to said field between said electrode members pile forming fibers which tend to tree therein, and means for agitating the web of foundation material while it is positioned within said field, whereby treeing is minimized.

24. The method of producing pile-surfaced sheet material which comprises providing an electrical field of intermittently varying strength, positioning an adhesive-surfaced foundation material in said field, supplying pile-surface forming fibers to said field, and agitating the foundation material while in said field.

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[fol. 696]

5

CERTIFICATE OF CORRECTION.

Patent No. 2,173,078. September 12, 1939.

ARCHIBALD F. CRESTON.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, line 5, before the word "involves" insert by a process which; and second column, line 32, for "member 8" read member 9; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of November, A. D. 1939.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

[fol. 697]

Sept. 26, 1939. A. F. MESTON ET AL. 2,174,328

FILED SURFACE IN PATTERN FORM

Original Filed Feb. 6, 1935 2 Sheets-Sheet 1

Fig. 1.

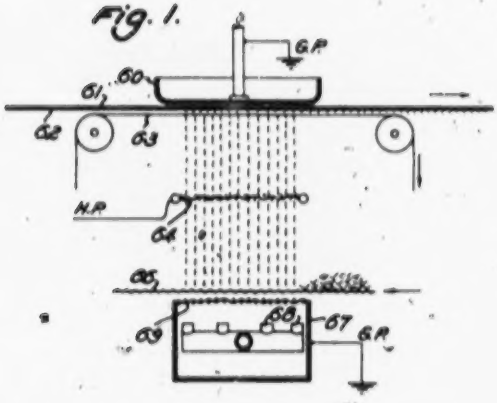
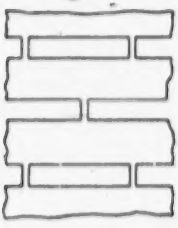


Fig. 2.

Fig. 3.



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[fol. 698]

Sept. 26, 1939. A. F. MESTON ET AL. 2,174,328

FILED SURFACE IN PATTERN FORM

Original Filed Feb. 6, 1935 2 Sheets-Sheet 2

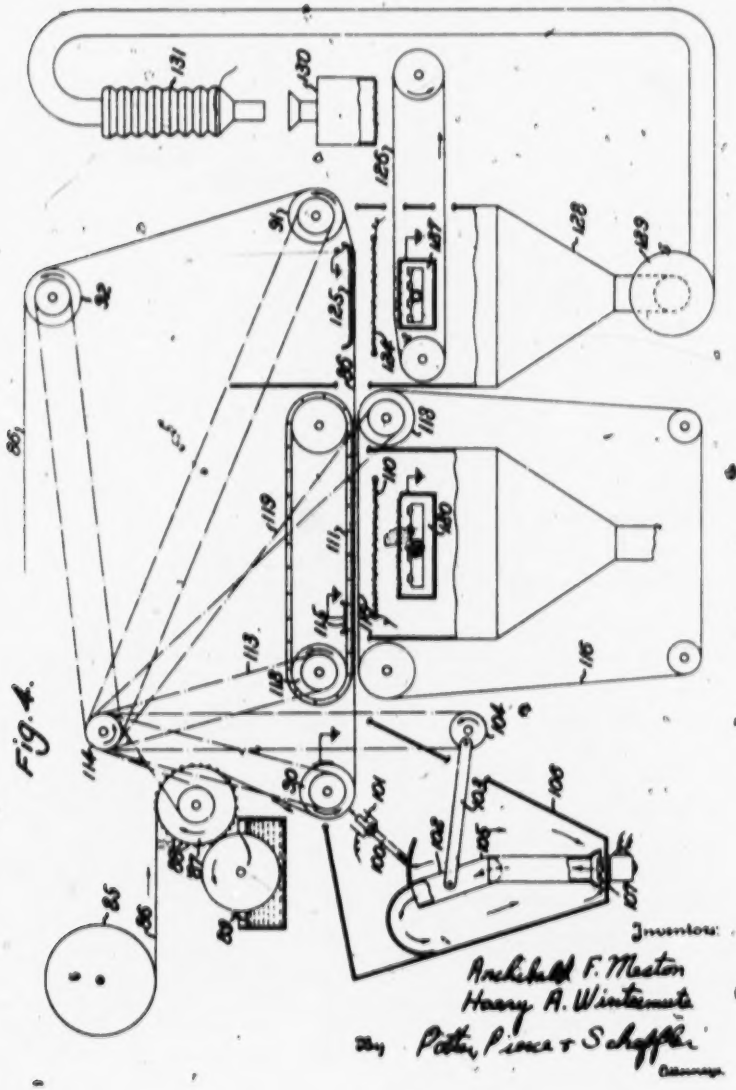

Fig. 4.

Patented Sept. 26, 1939

2,174,328

UNITED STATES PATENT OFFICE

2,174,328

PILED SURFACE IN PATTERN FORM

Archibald F. Meston, Round Brook, and Harry A. Wintermute, Plainfield, N. J., assignors, by mesne assignments, to Behr-Manning Corporation, a corporation of Massachusetts

Original application February 6, 1935, Serial No. 5,288. Divided and this application March 28, 1937, Serial No. 132,170

5 Claims. (Cl. 91—8)

This invention relates to coating and/or decorating surfaces with simulated piles in pattern form. It has to do in particular with apparatus and methods for making and controlling a non-uniform electric field used in the deposition of elongated particles on adhesive covered surfaces for the purpose of effecting a topical arrangement of the particles on the surfaces, for example, in pleasing patterns.

Fibers, such as rayon flocks, can be deposited in oriented position upon an adhesive covered surface if the surface is positioned in an electric field and fibers are introduced into the electric field in unrestrained manner. The conditions required for satisfactory deposition of fibers in the piling of surfaces are described in copending applications Serial No. 692,201, A. F. Meston, filed October 4, 1933; and Serial No. 699,456, H. A. Wintermute, filed November 23, 1933.

The piles made with the apparatus and methods used and described in the applications just mentioned are quite uniform in composition and appearance. Most of the fibers stand erect, perpendicular to the surface, making piles of monotonous evenness from a decorative standpoint. It has now been found that by suitable control of the electric field by means of which the fibers are deposited, and particularly by the use of a deliberately warped or discontinuous electric field, pleasing variations and definite patterns can be obtained in the pile.

Apparatus useful in carrying out the invention and several embodiments of the invention, including novel methods and products, are hereinafter described with particular reference to the appended drawings, in which:

Fig. 1 is a diagrammatic view, in side elevation, of apparatus for depositing fibers in pattern formation by utilizing a moving field stencil;

Figs. 2 and 3 show typical forms of field stencils used with the invention; and

Fig. 4 is a diagrammatic view in side elevation of apparatus for the production of material having a piled surface in pattern form, including the features of the present invention together with features more particularly described and claimed in our application Serial No. 5,288, filed February 6, 1935, of which the present application is a division.

In the apparatus of Fig. 1 a field controlling member is supported in an electric field established between a high potential electrode and a ground electrode. The field control or field stencil member is positioned in front of the surface being piled and is preferably at the same or nearly the same potential as the electrode just back of the sheet with the surface being piled. In the figure electrode 66 is preferably flat and is at ground potential. Electrode 64 is of reticulated construction or the like and is maintained at a high potential. Sheet 61, the under side 62 of which is to be piled, is moved through the electric field between electrodes 66 and 64, preferably just under and touching electrode 66, as shown. A member 63, advantageously formed as a belt with stencil-like perforations such as the diamond design shown in Fig. 2 or the slots shown in Fig. 3, is moved parallel with and at the same speed as sheet 61. It is held a short distance, for example, one-fourth inch, in front of adhesive covered surface 62. The fibers to be deposited are brought into the apparatus on a moving porous belt 60. When the fibers are carried by belt 60 over the top of wind box 67, compressed air issuing from nozzles 68 and passing through regulating means 69 blows through the interstices of belt 60 and blows the fibers up through electrode 64 and into the electric field for deposition on surface 62. Very definite patterns are made with the apparatus shown in Fig. 1 and they can be made very colorful if the sheet to be piled is passed through several partially shielded fields, each one depositing fibers of a different color.

Belt 63 can be made of wire or other attenuated members woven into a pattern and it will influence the deposition of the fibers comprising the pile by altering the electric field. Or belt 63 can be made up as a stencil and cause a pattern to be made by definitely covering portions of surface 62 and permitting flocks to be deposited only behind openings in the stencil. Besides the diamond pattern shown in Fig. 2, decorative designs, such as flowers, and commercial outlines comprising names, can be formed. Such stencil-like members effect the pattern not only mechanically but also effect it by locally altering the characteristics and intensity of the electric field and therefore they may be designated as "field stencils."

Fig. 4 is a diagrammatic view in side elevation of apparatus which may be used in successively applying the several embodiments of the invention which have been described in this application and our application Serial No. 5,288, filed February 6, 1935. A sheet 86 of the material to be piled, for example, a light weight, flexible but closely woven textile, is unwound from supply roll 88, passed over an adhesive applying roll 81, over positioning and tensioning rolls 90, 91

[fol. 700]

and 87, and through means, not shown, for finishing and storing the piled product. Roll 87 is shown with raised portions 88 to apply the adhesive from vessel 89 to the surface of sheet 86 in restricted areas only. Where the surface of the sheet is to be completely piled, a smooth roll to spread adhesive over the entire surface of the sheet is used.

As the adhesive coated sheet goes over roll 88, it may be sprayed with fibers from one or more spray electrodes 101 in accordance with the practice described in application Serial No. 5,288. The fibers for sprays 101 are supplied through conduit 102 and this can be made to move away from the entrance of sprays 101 by reciprocating means, for instance, crank 104 acting, preferably with a quick return movement, through connecting-rod 103, will make conduit 102 articulate at joint 105 at the chosen intervals when deposition of particles is to be interrupted. During the period of interruption the fibers blow out the end of conduit 102 and fall to the bottom of casing 100 to be lifted again by blower 101. If electrode 101 is maintained at high potential connecting tube 100 is made of insulating material.

Sheet 86 next passes through an electric field established between screen electrode 110 and control electrode 111. The latter electrode can be in the form of any of the control electrodes shown in application Serial No. 5,288, but is made into or is attached to an endless band. If electrode 111 is to cause the fibers to deposit in a closed pattern or one with transverse marks, it must move at the same speed and in the same direction, as sheet 86 while sheet 86 is moving through the electric field above electrode 110. This is accomplished by turning pulley 112, over which electrode 111 passes, by a positive drive 113 such as a chain from a source of power 114 which also turns pulley 90 over which sheet 86 passes, in positive manner. Positive synchronous movement of belt and electrode can also be obtained by having spurs project from the edge of electrode 111 and engage perforations along the edges of sheet 86 in the manner known to the moving picture art. A grounded shoe 115 contacts electrode 111 and maintains it at ground potential.

Underneath sheet 86 a belt 116 may be positioned by utilizing supporting pulley 117 and supporting and propelling pulley 118. Belt 116 may be perforated as a stencil and function as a field stencil in the manner of member 93 in Fig. 1. The stenciling belt must move at the same speed as sheet 86 and such movement is obtained through drive 119. Other field altering means, such as screens, can be used in place of stenciling means 116, and such means travelling at the speed of sheet 86 will give the pile on sheet 86 a woven appearance. Although pattern control electrode 111 and stenciling or other field altering means 116 can be used at the same time, ordinarily this is not done. A flat stationary electrode may be used in place of special electrode 111 when a field stencil is being used in front of sheet 86. Fibers are supplied to the field between electrodes 110 and 111 by supply means 120 in which air jets are utilized to project the fibers up through electrode 110.

Electrodes 124 and 126 in Fig. 4 are energized and used to deposit fibers if portions of the surface of sheet 86 remain unpiled after the sheet passes through the processing steps described in the above. No special effect is sought in this last step. Both electrodes have, in general, flat surfaces and the uniform field that results from impressing a high voltage across electrodes 124 and 126 tends to deposit an erect uniform pile. The deposition of fibers in this step is usually for the purpose of completing the pile started with spray electrodes 101 and/or the pile deposited through field stencil 116 and this filling is often made with fibers of a different color from that used in the preceding steps.

Apparatus for satisfactorily supplying fibers to the field between electrodes 124 and 126 is shown diagrammatically under electrode 124. It comprises an endless foraminous conveying belt 129 upon which fibers are spread by a distributor 130, preferably agitated, and a blowing means 127 that distributes air under pressure under belt 129 and causes it to pass up through the belt and raise the fibers therefrom and blow them through screen electrode 124. Unutilized fibers are collected in hopper 128 and conveyed by an air stream set in motion by fan 129 to filter bag collector 131 and thence to distributor 130.

Fig. 4 illustrates apparatus with a wide range of usefulness in the forming of artificial piles on adhesive covered surfaces. It is illustrative of the wide variation in methods and means for obtaining useful patterns in the electrical deposition of pile forming materials by the local alteration of the characteristics of the electrical field effecting the deposition, so as to produce a definite typical non-uniformity therein. It is obviously subject to a very large degree of variation and may be provided with electrode rapping or agitating means and other devices and modifications.

This application is a division of our application Serial No. 5,288, filed February 6, 1935, now Patent 2,152,077.

We claim:

1. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrode means for maintaining a high potential difference between said electrodes to establish an electric field therebetween whereby attenuated fibers introduced into said field are caused to be projected towards one of said electrodes, means positioned between the electrodes for causing local concentrations of the electric field between said electrodes, means for positioning an adhesive-surfaced base material in the non-uniform portion of said field, and means for supplying attenuated fibers to said field between said field concentrating means and the other electrode.

2. Apparatus for electrically depositing attenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween whereby attenuated fibers introduced into said field are caused to be projected towards one of said electrodes, a member positioned in the field between said electrodes having perforations extending therethrough in the direction of the lines of force of said field, means for passing an adhesive-surfaced base material through the electric field between said member and said electrode, and means for supplying attenuated fibers to said field between said member and the other electrode.

3. Apparatus for electrically depositing at-

tenuated fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising complementary electrodes, means for maintaining a high potential difference between said electrodes to establish an electric field therebetween whereby attenuated fibers introduced into said field are caused to be projected towards one of said electrodes, a member positioned in the field between said electrodes having perforations extending therethrough in the direction of the lines of force of said field, means for passing an adhesive-surfaced base material through the electric field between said member and said electrode, means for moving said member substantially synchronously with said base material, and means for supplying attenuated fibers to said field between said member and the other electrode.

4. Apparatus for electrically depositing fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising opposed complementary electrodes, means for impressing a high potential difference between said electrodes to establish an electric field therebetween whereby attenuated fibers introduced into said field are caused to be projected towards one of said electrodes, means for positioning an adhesive-surfaced base material in the electric field adjacent the electrode toward which the fibers are projected by the field, a member positioned in the field between said base material and the other of said electrodes having perforations extending therethrough in the direction of the lines of force of said field, and means for supplying attenuated fibers to said field between said member and said other electrode.

5. Apparatus for electrically depositing fibers upon an adhesive coated surface to form a pile thereon in pattern form, comprising opposed complementary electrodes at least one of which presents an extended substantially plane surface to the opposing electrode, means for impressing a high potential difference between said electrodes to establish an electric field therebetween whereby attenuated fibers introduced into said field are caused to be projected towards an extended surface electrode, means for positioning an adhesive-surfaced base material in the electric field adjacent the electrode toward which the fibers are projected by the field, a member extending through said field in substantially parallel relation to said extended surface electrode between said base material and the other of said electrodes having perforations extending therethrough in the direction of the lines of force of said field, and means for supplying attenuated fibers to said field between said member and said other electrode.

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[fol. 702]

Oct. 8, 1940. A. F. MESTON ET AL 2,217,126

FILED SURFACE IN PATTERN FORM

Original Filed Feb. 6, 1935 4 Sheets-Sheet 1

Fig. 1.

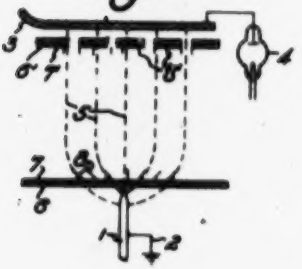

Fig. 2.

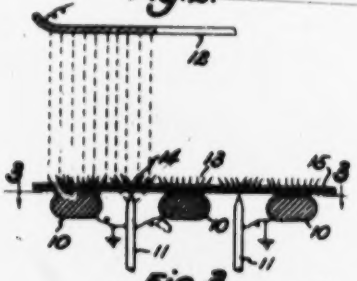

Fig. 3.

Fig. 4.

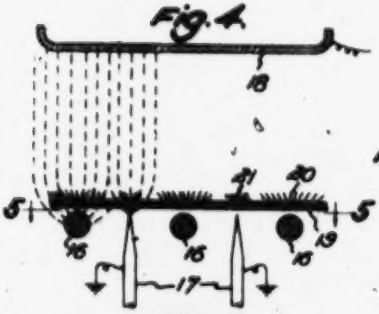

Fig. 5.

Fig. 6.

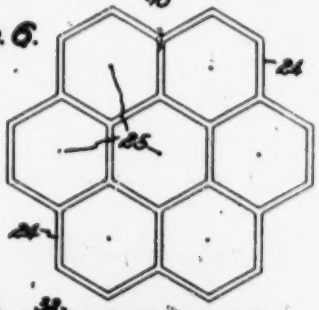

Fig. 7.

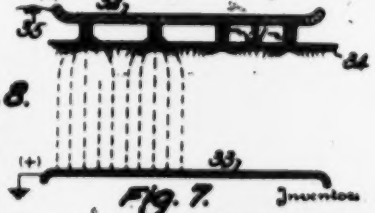

Fig. 8.

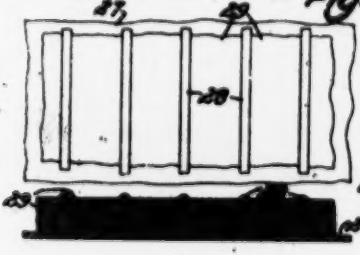

Fig. 9.

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[fol. 703]

Oct. 8, 1940. A. F. MESTON ET AL 2,217,126

FILED SURFACE IN PATTERN FORM

Original Filed Feb. 6, 1936 6 Sheets-Sheet 2

Fig. 10.

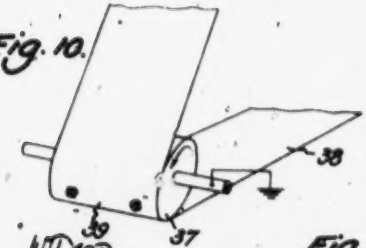


Fig. 11.

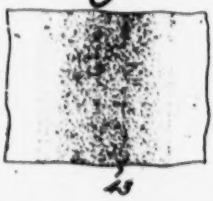


Fig. 12.

Fig. 13.

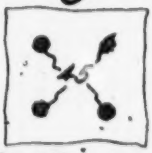


Fig. 14.

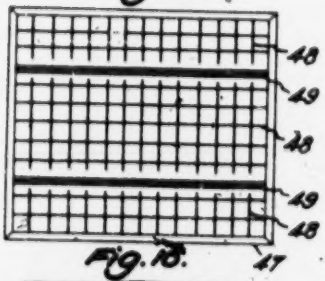


Fig. 15.

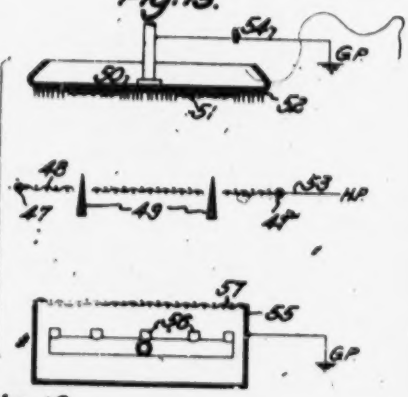


Fig. 16.

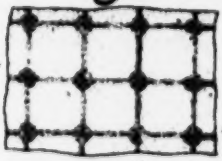


Fig. 17.

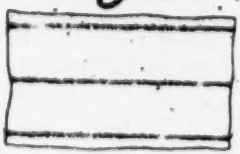
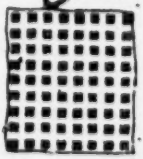


Fig. 18.



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[fol. 704]

Oct. 8, 1940. A. F. MESTON ET AL 2,217,126

FILED SURFACE IN PATTERN FORM

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Fig. 19.

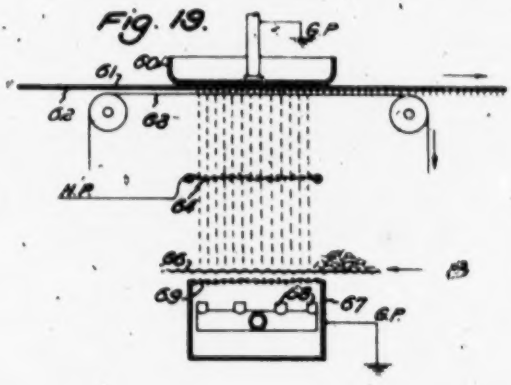

Fig. 20.

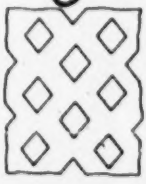

Fig. 21.

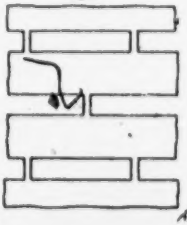

Fig. 23.

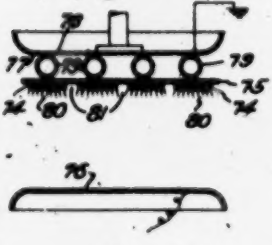

Fig. 22.

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Original Filed Feb. 6, 1936 4 Sheets-Sheet 4.

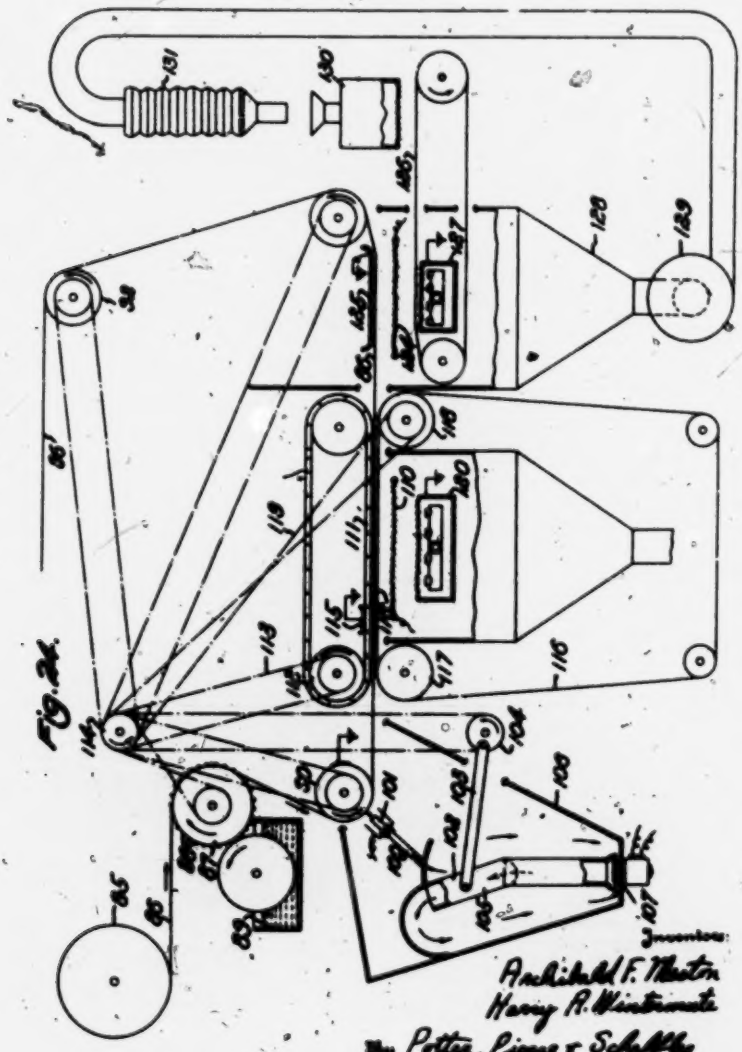

Fig. 24.

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Patented Oct. 8, 1940

2,217,126

UNITED STATES PATENT OFFICE

2,217,126

PILED SURFACE IN PATTERN FORM

Archibald F. Mouton, Round Brook, and Harry A. Winternute, Plainfield, N. J., assignors, by mesne assignments, to Bakelite Corporation, a corporation of Massachusetts

Original application February 6, 1933, Serial No. 655,393. Divided and this application March 30, 1937, Serial No. 132,389

3 Claims. (Cl. 41—36)

This invention relates to coating and decorating surfaces with simulated piles in pattern form and is particularly directed to the novel pile surfaced material thereby produced.

Fibers, such as rayon flocks, can be deposited in oriented position upon an adhesive covered surface if the surface is positioned in an electric field and fibers are introduced into the electric field in unrestrained manner. The conditions required for satisfactory deposition of fibers in the piling of surfaces are described in copending applications Serial No. 692,391, A. F. Mouton, filed October 4, 1933, and Serial No. 699,484, H. A. Winternute, filed November 22, 1933.

The piles made with the apparatus and methods used and described in the applications just mentioned are quite uniform in composition and appearance. Most of the fibers stand erect, perpendicular to the surface, making piles of monotonous evenness from a decorative standpoint. It has now been found that by suitable control of the electric field by means of which the fibers are deposited, and particularly by the use of a deliberately warped or discontinuous electric field, pleasing variations and definite patterns can be obtained in the pile.

A principal purpose of the invention is the production of pile surfaced material comprising a foundation web having a binder in its surface and fibers attached to the web by the binder which vary topically in concentration or inclination or both to form a pattern.

Apparatus useful in carrying out the invention and several embodiments of the invention, including novel methods and products, are hereinafter described with particular reference to the appended drawings, in which:

Fig. 1 is a diagrammatic side view of complementary electrodes and an electric field therebetween in which fibers are being attracted by the forces prevailing in a non-uniform portion of the field;

Fig. 2 is a fragmentary view in side elevation of an assembly of electrode elements as used in the deposition of fibers in accordance with the invention;

Fig. 3 is a fragmentary plan view of what is shown in Fig. 2 taken at 3—3;

Figs. 4 and 5 are fragmentary views comparable to Figs. 2 and 3, respectively, showing the utilization of somewhat different elements in the electrode structure used with the invention;

Fig. 6 is a plan view of another arrangement of electrode elements useful in setting up a non-uniform field in accordance with the invention;

Fig. 7 illustrates in side view the forming of a patterned pile on a base sheet, with still another arrangement of electrodes;

Figs. 8 and 9 are fragmentary plan and side views, respectively, of another electrode assembly that can be used advantageously with the invention;

Fig. 10 indicates, perspectively, apparatus including air jets useful in applying fibers to surfaces in accordance with the invention;

Figs. 11, 12 and 13 show with plan views, the types of patterns which can be obtained with the apparatus illustrated in Fig. 10;

Fig. 14 is a plan view of a fortuitous electrode comprising corona forming elements, useful in practicing the invention;

Fig. 15 shows diagrammatically in end elevation, apparatus for utilizing the electrode shown in Fig. 14;

Figs. 16, 17 and 18 are views of fragmentary portions of products made with reticulated electrodes;

Fig. 19 shows diagrammatically, in side elevation, apparatus for depositing fibers in pattern formation, by utilizing a moving field-stencil;

Figs. 20 and 21 show typical forms of field stencils used with the invention;

Fig. 22 illustrates, in side view, an adhesive applying roll with cut-away portions;

Fig. 23 shows, in sectional elevation, an electrode assembly useful in depositing fibers on a surface coated with the roll shown in Fig. 22; and

Fig. 24 is a diagrammatic view in side elevation of apparatus that permits the utilization of the various electrodes and other means illustrated in the various figures and the carrying out of the several methods of the invention to be hereinafter described.

In Fig. 1, numerals 1 and 2 identify electrodes between which an electric field has been established; electrode 1 is grounded as indicated at 2 and electrode 2 is insulated from ground and connected to a source of high potential constant polarity current represented by tube rectifier 4. The so-called lines of force of the electric field represented by lines 5 leave the electrodes perpendicular to the surface. Electrode 1 has a pointed or rounded top and the lines of force curve and spread out in the manner shown as they leave the small area presented by the top of the electrode. Opposing or complementary electrode 2, on the other hand, has a flat surface upon which the lines of force terminate and the

lines of force in the vicinity of this electrode are straight, parallel, and uniformly distributed.

When a non-conducting sheet 6 covered with adhesive 7 is positioned between electrodes 1 and 3 and short fibers are freely suspended in the electric field the fibers are oriented and attached to the adhesive covered sheet parallel to the lines of force passing through the sheet at the point of attachment. Once attached they maintain the position of original attachment and resist re-alinement by forces that may be applied subsequently. When the sheet to be piled with fibers is placed in the position marked 5', the fibers are attached in the positions 8', 9' and a uniform pile of upright fibers is obtained. But if a sheet is held against, or a short distance from, electrode 1, the fibers are attached at angles to the perpendicular as indicated at 8, 9 because of the inclined positions of the lines of force 5 in this region of the electric field. For instance, the field near a point causes the fibers to become arranged like the petals of a flower.

In Figs. 2 and 3, the electrode elements over which the adhesive covered sheet 16 is positioned while being piled comprises members 10 with a more or less extended top surface and members 11 with very restricted or ...ped top surfaces. The complementary electrode 12 is preferably flat or has an extended surface. The arrangement of the fibers in the pile made with the electric field between electrode elements 10 and 11 and electrode 12 is shown in Fig. 2. The fibers 13 over the extended positions 10 are deposited in erect position except perhaps over the edges of elements 10, while the fibers 14 over edges 11 are deposited in the inclined positions shown and provide a striped effect. This pattern can be made while the sheet is moving in the direction of the arrow in Fig. 2, but if it is desired to have the stripes extend crosswise of the sheet, the electrode elements 10 and 11 must move at the same speed as the sheet.

In Figs. 4 and 5 the electrode assembly which influences the deposition of the fibers is made up of bars 16 and pointed members 17. Complementary electrode 18 has a flat extended surface. The pile formed with these electrode elements, assembled as shown, comprises parallel stripes with spots between them, the stripes being formed of fibers 20 deposited over rods 16 perpendicular to sheet 19 except at the edges and the spots being formed of fibers 21 which are deposited over points 17 in inclined positions. The smaller the diameter of rods 16 and the closer these are to the sheet 19 being piled, the more the fibers at the edges of the stripes lean outward and set off the stripes, and the closer points 17 are to sheet 19 the more pronounced is the inclination of the fibers in points 21.

By varying the relative positions of the electrode elements in Figs. 4 and 5 the pattern formed will present various effects. The electrical connections can be varied also. It will be noted that while elements 10 in Fig. 2 are grounded, elements 16 in Fig. 4 are not connected to ground, but are allowed to electrically "float" on insulating supports (not shown) and to take the voltage resulting from their position in the electric field. If the sheet being piled is held stationary during the deposition of the fibers the pattern will comprise stripes with dots between, but if the sheet is moved during deposition the electrode elements, at least points 17, must move at the same speed as the sheet or streaks will result in the pattern over the points.

Fig. 6 is a plan view of an assembly of electrode elements not unlike the assembly shown in Fig. 5, but in Fig. 6 the bars (similar to those marked 16 in Fig. 5) making up member 24 have been joined together to form a single continuous element. Points 25, one of which is positioned in the center of each individual hexagon, have been found to alter the electric field in such manner that the pile deposited t... comprises hexagon figures of unusual interes... The fibers are inclined at various angles and when looking at the pile from first one and then another position the sheen changes, displaying many fragments of hexagons, some lustrous and some of which are dull. Of course, to provide a closed pattern like the one made with the electrode of Fig. 6, the electrode must participate in any movement undergone by the surface being piled, as will be described, for example, in connection with Fig. 24.

In Fig. 7, elements 31 are strips of insulating material, for instance, of hard rubber or phenol condensation products, attached to a conducting plate 32. Dielectric material with a specific inductive capacity several times that of air, examples of which are porcelain, mica or "Bakelite," when placed in an electric field, will locally concentrate the lines of force in the field in the vicinity of the pieces of dielectric. The arrangement shown in Fig. 7 has conducting plate 32 connected through conductor 36 to a source of unidirectional current at a potential of, say, 70,000 volts above ground. Complementary electrode 33 is positioned some 4 inches below member 32 and is maintained at ground potential. Elements 31 are, therefore, positioned in the strong electric field that exists between electrodes 32 and 33 and tend to concentrate the lines of force as they approach electrode 32.

Now if an adhesive covered surface, as sheet 34, that is not conducting, is placed just in front of elements 31 and fibers are suspended in the electric field above electrode 33, or distributed over the surface of electrode 33, many of the fibers will be raised and oriented by the electrical field and attracted to electrode 32. The fibers will move with their long axis parallel to the electric lines of force and become attached to the adhesive covered under surface of sheet 34 in the inclined positions shown. In this embodiment of the invention the electric field is warped by placing insulating members of sharp curvature or limited area before a conducting member, preferably a simple member of extended area, whereas in the apparatus illustrated in Figs. 1, 2, 4 and 6, warped fields are established by providing conducting elements of sharp curvature and limited area. The insulating strips 31 in Fig. 7 can be formed into geometrical figures, letters and the like, thus permitting a wide variety in the patterns formed.

Figs. 8 and 9 illustrate another electrode structure comprising insulating material used with certain embodiments of the invention. It is made up of a conducting base plate 27, conducting elements 28, here shown as narrow strips with rounded tops, and dielectric material 29 between the strips. Electrodes of this construction give very striking results. The sheet to be piled is placed parallel to the top surface of material 29 and touching or closely adjacent the top (exposed) edges of members 28 and a complementary electrode is positioned at a proper distance —2 to 5 inches, depending upon conditions— above 29 as electrode 12 is positioned above mem-

[fol. 708]

bers 16 in Fig. 2. The pile deposited when a strong electric field is established between the electrodes shows very pleasing shaded stripes, probably due to peculiar distortions in the electric field produced at top of elements 28 where they emerge from insulating material 29. The arrangement of the conductive members with relation to the insulating material has been found to have a considerable effect on the patterns produced. With the electrode shown in Figs. 8 and 9, very good patterns have been obtained with conducting edges 28 projecting about 1/8 to 1/4 inch above the surface of dielectric filler 29.

In those embodiments of the invention shown in Figs. 1 to 9, inclusive, the controlling electrode, that is the electrode influencing the pattern in the pile most greatly, is placed just back of the sheet or other member, the surface of which is to be piled. The adhesive coating is placed on the side of the sheet away from the controlling electrode and faces the complementary electrode which furnishes a surface upon which the other end of the electric field terminates. For example, in Fig. 4, elements 16 and 17 comprise the controlling electrode, member 16 is the complementary electrode, and 19 is the sheet being piled with the adhesive coating on the side of the sheet away from electrode 16, 17. Figs. 6, 8 and 9 show no complementary electrodes, but it is to be understood that in using the controlling electrodes shown in these figures, suitable opposing or complementary electrodes are also used. The electrodes can be positioned so that the fibers move downward to become attached to the coated surface, as in Fig. 2, or the electrodes can be arranged to cause the fibers to move upward as in Fig. 7. The latter arrangement, or an arrangement with vertically positioned surfaces, is advantageous because such arrangements make easy the jarring of loose and poorly attached fibers from the sheet during the piling operation.

The electrode farthest from the sheet is not of such contour, usually, that it influences the pattern in the pile and is often made as a simple, flat, non-discharging surface. But as will be explained hereinafter, the electrodes away from the sheet to be piled can greatly influence the deposition of the fibers comprising the pile.

The sheet to be piled in Fig. 10 is positioned adjacent an electrode of smooth contour, in this instance, a roll 37 and corona-forming, complementary electrodes 40 are responsible for the pattern effect in the pile. It has been found that if the fibers to be electrically deposited are introduced through a tube about which corona discharges are present, desirable results in patterned piles can be obtained. In Fig. 10, sheet 38 travels about a grounded roll 37 which preferably turns to avoid friction and exposes an adhesive covered surface 39 to electrodes 40, each made up of a tube 41 and discharge points 42. It has been found that if wire points 43 are left off when rayon flocks or similar fibers are blown through tubes 41 and the tubes are connected to a source of unidirectional high potential current, the flocks become scattered as they are deposited. Such a result is shown at 43 in Fig. 11. With points 42 attached to and arranged about high potential tubes 41, the flocks are concentrated locally as illustrated in Figs. 12 and 13. If sheet 38 moves while electrodes 40 are stationary, but continuously depositing fibers, stripes 44 are formed. If the fibers are deposited only while sheet 38 is stationary, or while it is moving at the same speed as electrodes 40 are caused to move, spots are formed such as those marked 45 in Fig. 13. Other factors controlling the pattern produced are the size of the tubes or nozzles, the velocity of the air stream, the emphasis given the corona emanating from the points as caused by variously positioning the points about the end of the tube, and the strength of the electric field.

The stripes or points deposited with the electrode assembly in Fig. 10 may be insufficient in themselves to form a pleasing pattern. Advantageously all of surface 39 is covered with adhesive, then spots are first deposited in one color in the manner just described, and then the sheet is moved into another part of the apparatus shown in Fig. 24 where the unpiled surface is covered with fibers of a different color. Not only can the fibers successively deposited be of different colors, but they can be of different length and/or luster, and by controlling the characteristics of the electric field and the length of treatment the spots or stripes can be made to have a very different appearance from the pile filled in between. The furs of certain animals, the silver fox, for instance, can be imitated by using the method just described.

It has been found desirable in the electrical attachment of fibers to form a pile to have the fibers approach the surface to be piled separately, not in clumps or "treed" together. Screens may be used to break up grouped fibers as they are floated in air streams into the electric field and a simple manner of using a screen or other foraminous member for this purpose is to have it function as one of the electrodes. Figs. 14 and 15 show an electrode 47 that functions as a complementary electrode to grounded electrode 38. Electrode 47 of conducting material is insulated from ground and positioned about four inches below electrode 38 and is connected by conductor 53 to a source of unidirectional high potential current. It functions also to break up clumps of fibers blown by air jets 56 from supply means 55 that are not completely disintegrated by disintegrating means 57. It has been discovered that a foraminous electrode, positioned and used as is electrode 47 in Figs. 15, can be caused to influence the arrangement of fibers as they are electrically deposited on a surface,—on the surface of sheet 52, for example, as it is held adjacent 38. One way of altering the pile formed of the deposited fibers is to make foraminous electrode 47 with edges 48 projecting through surface 48 which is preferably of screen. The electric field adjacent edges 48 is so concentrated when a high voltage drop is impressed across electrodes 47 and 38 that corona discharges emanate from the edges and the fibers just over the edges deposit in other than erect positions as indicated at 51. Depressed stripe effects are given the pile formed with electrodes 47 and 38. Of course, points or edges arranged in patterns could be substituted for edge members 48 in electrode 47.

Figs. 16, 17 and 18 are plan views of fragments of patterned piles which may be made with the controlling electrodes spaced from the surface being piled. The pattern shown in Fig. 16 is made with an electrode of wire net of coarse mesh (1/2 to 3/4") located in the position of electrode 47 in Fig. 15. A very strong electric field is used to deposit the fibers, but not strong enough to force the fibers down into the adhesive, such as results from quite definite corona discharges. The pile in Fig. 17 results from the use of an electrode comprised of parallel wires and that shown in Fig. 18 may be made with a net of

rather small mesh used as a controlling electrode and positioned several inches from the adhesive covered surface being piled. The piles shown in Figs. 16, 17 and 18 are characterized by having lines and/or dots standing out prominently as local concentrations of fibers.

Fig. 19 illustrates apparatus in which the field controlling member is supported in front of the surface being piled, but is preferably at the same or nearly the same potential as the electrode just back of the sheet with the surface being piled. Electrode 66 is preferably flat and is at ground potential. Electrode 64 is of reticulated construction or the like and is maintained at high potential. Sheet 61, the under side 62 of which is to be piled, is moved through the electric field between electrodes 66 and 64, preferably just under and touching electrode 66, as shown. A member 63, advantageously formed as a belt with stencil-like perforations such as the diamond design shown in Fig. 20 or the slots shown in Fig. 21, is moved parallel with and at the same speed as sheet 61. It is held a short distance, for example one-fourth inch, in front of adhesive covered surface 62. The fibers to be deposited are brought into the apparatus on a moving porous belt 68. When the fibers are carried by belt 68 over the top of wind box 67, compressed air issuing from nozzle 69 and passing through regulating means 69 blows through the interstices of belt 68 and blows the fibers up through electrode 64 and into the electric field for deposition on surface 62. Very definite patterns are made with the apparatus shown in Fig. 19 and they can be made very colorful if the sheet to be piled is passed through several partially shielded fields, each one depositing fibers of a different color.

Belt 63 can be made of wire or other attenuated members woven into a pattern and it will influence the deposition of the fibers comprising the pile by altering the electric field. The resulting patterns will be much like those shown in Figs. 16 and 17, but in more striking relief. Or belt 63 can be made up as a stencil and cause a pattern to be made by definitely covering portions of surface 62 and permitting flocks to be deposited only behind openings in the stencil. Besides the diamond pattern shown in Fig. 20, decorative designs, such as flowers, and commercial outlines, comprising names, can be formed. Such stencil-like members effect the pattern not only mechanically but also effect it by locally altering the characteristics and intensity of the electric field and therefore they may be designated as "field stencils."

Figs. 22 and 23 illustrate apparatus adapted to apply adhesive locally to a surface and then to pile the adhesive covered portions in accordance with the invention. In Fig. 22, adhesive applying roll 71 has cut away portions 72 and raised portions 73. Only the raised portions carry adhesive to the surface to be piled and in the figure a transverse cross-section of a sheet 76 is shown with stripe of adhesive 74 applied thereto by raised portions 73. Fig. 23 shows sheet 76 after having been locally coated with adhesive with roll 71 passing through a strong electric field between complementary electrodes 76 and 77. Electrode 77 comprises a conducting plate 78 on the bottom surface of which tubes 79, or other members of small surface area which may be but are not necessarily conducting, are attached. Tubes 79 are spaced to correspond with the spacing of raised portions 73 on applicating roll 71. Sheet 76 is positioned under and adjacent tubes 79 and, for continuous operation, is moved in a direction parallel to the tubes. The pile 80 deposited on adhesive stripe 74, by action of the electric field in the manner previously described, is not uniformly erect, but leans outwardly at the edges and projects into unpiled spaces 81. The inclined positions of some of the fibers is due to the directions taken by the lines of force of the electric field approaching the surfaces of tubes 79. The effect of the inclined fibers partially covering spaces 81 is especially striking when the fibers are of one color and sheet 76 is of another color.

Fig. 24 is a diagrammatic view in side elevation of apparatus which may be used in successively applying the several embodiments of the invention which have been described. A sheet 86 of the material to be piled, for example, a light weight, flexible but closely woven textile, is unwound from supply roll 83, passed over an adhesive applying roll 87, over positioning and tensioning rolls 88, 81 and 82, and through means, not shown, for finishing and storing the piled product. Roll 87 is shown with raised portions 88 to apply the adhesive from vessel 89 to the surface of sheet 86 in restricted areas only as in that embodiment of the invention illustrated by Figs. 22 and 23. Where the surface of the sheet is to be completely piled, a smooth roll to spread adhesive over the entire surface of the sheet is used.

As the adhesive coated sheet goes over roll 88, it may be sprayed with fibers from one or more spray electrodes 101 in accordance with the practice described in connection with Figs. 10, 11, 12 and 13. If the spray electrodes 101 are operated continuously, lines of fibers are deposited upon sheet 86 as shown in Fig. 13, but if the spraying is done at intervals only, spaced patches such as the spots shown in Fig. 13 will be deposited. The fibers for sprays 101 are supplied through conduit 102 and this can be made to move away from the entrands of sprays 101 by reciprocating means, for instance, crank 104 acting, preferably with a quick return movement, through connecting rod 105 will make conduit 102 articulate at joint 103 at the chosen intervals when deposition of particles is to be interrupted. During the period of interruption the fibers blow out the end of conduit 102 and fall to the bottom of casing 100 to be lifted again by blower 107. If electrode 101 is maintained at high potential connecting tube 106 is made of insulating material.

Sheet 86 next passes through an electric field established between spray electrode 110 and control electrode 111. The latter electrode can be in the form of any of the control electrodes shown in Figs. 1 to 9 inclusive, but is made into or is attached to an endless band. If electrode 111 is to cause the fibers to deposit in a closed pattern or one with transverse marks, it must move at the same speed and in the same direction as sheet 86 while sheet 86 is moving through the electric field above electrode 110. This is accomplished by turning pulley 112, over which electrode 111 passes, by a positive drive 113 such as a chain from a source of power 114 which also turns pulley 85 over which sheet 86 passes, in positive manner. Positive synchronous movement of belt and electrode can also be obtained by having spurs project from the edge of electrode 111 and engage perforations along the edges of sheet 86 in the manner known to the moving picture art. A grounded shoe 115 con-

tacts electrode 111 and maintains it at ground potential.

Underneath sheet 86 a belt 116 may be positioned by utilizing supporting pulley 117 and supporting and propelling pulley 118. Belt 116 may be perforated as a stencil and function as a field stencil in the manner of member 63 in Fig. 19. The stencilling belt must move at the same speed as sheet 86 and such movement is obtained through drive 119. Other field altering means, such as screens, can be used in place of stencilling means 116, and such means travelling at the speed of sheet 86 will give the pile on sheet 86 a woven appearance as indicated in Figs. 16 and 18. Although pattern control electrode 111 and stencilling or other field altering means 116 can be used at the same time, ordinarily this is not done. A flat stationary electrode may be used in place of special electrode 111 when a field stencil is being used in front of sheet 86. Fibers are supplied to the field between electrodes 110 and 111 by supply means 120 in which air jets are utilized to project the fibers up through electrode 110.

Electrodes 124 and 125 in Fig. 24 are energized and used to deposit fibers if portions of the surface of sheet 86 remain unpiled after the sheet passes through the processing steps described in the above. No special effect is sought in this last step. Both electrodes have, in general, flat surfaces and the uniform field that results from impressing a high voltage across electrodes 124 and 125 tends to deposit an erect uniform pile. The deposition of fibers in this step is usually for the purpose of completing the pile started with spray electrodes 101 and/or the pile deposited through field stencil 116 and this filling is often made with fibers of a different color from that used in the preceding steps.

Apparatus for satisfactorily supplying fibers to the field between electrodes 124 and 125 is shown diagrammatically under electrode 124. It comprises an endless foraminous conveying belt 126 upon which fibers are spread by a distributor 130, preferably agitated, and a blowing means 127 that distributes air under pressure under belt 126 and causes it to pass up through the belt and raise the fibers therefrom and blow them through screen electrode 124. Undeposited fibers are collected in hopper 128 and conveyed by an air stream set in motion by fan 129 to filter bag collector 131 and thence to distributor 130.

Fig. 24 illustrates apparatus with a wide range of usefulness in the forming of simulated piles on adhesive covered surfaces. It is illustrative of the wide variation in methods and means for obtaining useful patterns in the electrical deposition of pile forming materials by the local alteration of the characteristics of the electrical field effecting the deposition, so as to produce a definite topical non-uniformity therein. It is obviously subject to a very large degree of variation and may be provided with electrode rapping or agitating means and other devices and modifications.

This application is a division of our application Serial No. 5,288, filed February 6, 1935.

We claim:

1. A patterned pile-surfaced material comprising a base material, a continuous layer of binder material thereon and a substantially continuous coating of fibers having one end embedded in said binder material and the fibers in adjacent areas of said coating having different angles of inclination whereby a design of predetermined pattern is formed by the varying reflection of light.

2. A patterned pile-surfaced material comprising a base material, a continuous layer of binder material thereon and a substantially continuous coating of fibers having one end embedded in said binder material and the fibers in said coating locally varying in angle of inclination whereby a design of predetermined pattern is formed by the varying reflection of light.

3. A pile surface material comprising a continuous layer of binder material having fibers embedded therein at one end thereof, said fibers being disposed at locally varying angles of inclination to form a design of predetermined pattern by the varying reflection of light.

ARCHIBALD F. MESTON.
HARRY A. WINTERMUTE.

[fol. 711]

Oct. 15, 1940. H. A. WINTERMUTE 2,218,445

PRODUCTION OF FILE SURFACE MATERIALS

Filed Sept. 24, 1936 2 Sheets-Sheet 1

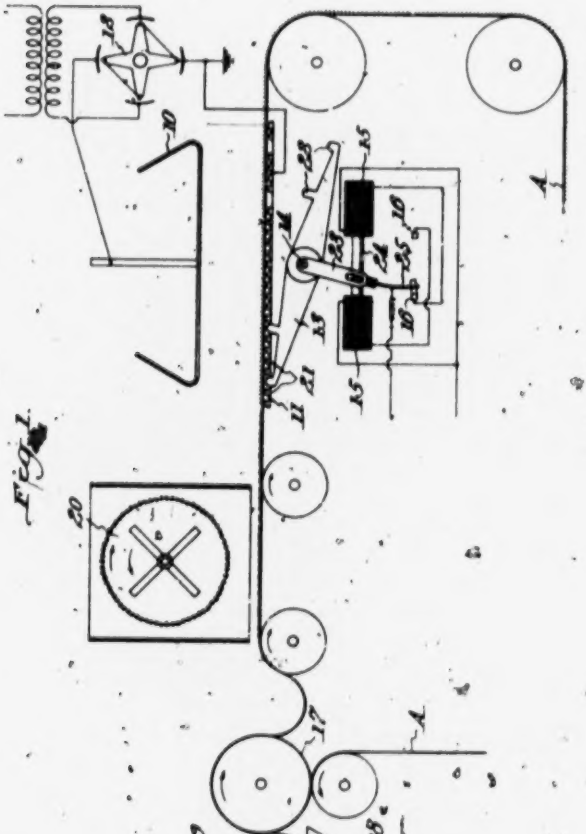

Fig. 1.

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[fol. 712]

Oct. 15, 1940. H. A. WINTERMUTE 2,218,445

PRODUCTION OF PILE SURFACE MATERIALS

Filed Sept. 24, 1936 2 Sheets-Sheet 2

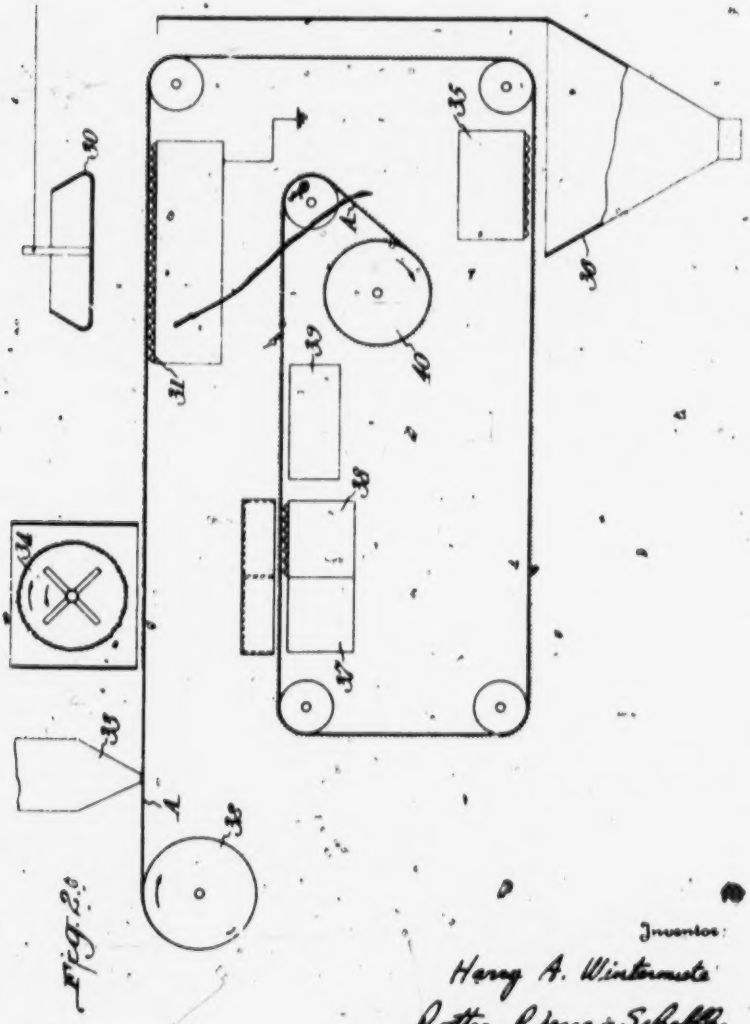

Fig. 2.

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[fol. 713]

Patented Oct. 15, 1940

2,218,445

UNITED STATES PATENT OFFICE

2,218,445

PRODUCTION OF PILE SURFACE MATERIALS

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Application September 24, 1938, Serial No. 231,326

2 Claims. (Cl. 91—70)

This invention relates to the production of pile-surfaced material and is particularly directed to a process and apparatus for the utilization of the combined effects of electrical and mechanical forces to produce artificially piled surfaces having a high degree of uniformity of appearance and an enhanced durability.

In the production of pile-surfaced materials by the deposition of pile-forming material, such as rayon flock, for example, upon adhesive coated bases, it has been found very difficult to obtain piles having a satisfactory uniformity of appearance and a satisfactory durability. Uniformity of appearance requires that the pile-forming material be uniformly distributed and also positioned at uniform angles. It has also been difficult to obtain artificial products having satisfactory resistance to wear.

It has now been found that pile-surfaced products of highly satisfactory durability and uniformity may be obtained by the method of the invention which comprises depositing pile-forming material upon an adhesive-surfaced backing, and subjecting the deposited pile material, before the adhesive is fully hardened, to a shaking or vibratory action while bringing within the orienting influence of a strong electric field, either alternating or unidirectional.

This method makes possible the production of a thicker pile than can be obtained by mechanical methods alone, while for a given thickness of pile the adherence of the fibers is greatly increased and the time required for the production of the pile is substantially shortened. The fibers stand more nearly normal to the surface, are more uniformly distributed, and are more uniformly oriented than when mechanical forces alone are used. The method of the invention is far less sensitive to air conditions, such as temperature and humidity, than methods involving the use of electric fields alone for depositing and orienting the fibers. Moreover, the fibers are more firmly fixed in the adhesive surface by the method of the invention than by the use of either the electric field or mechanical forces alone.

Various modifications of the method have been found to be advantageous for certain purposes. For example, a more durable bonding of the fibers may be obtained by subjecting the piled material to a subsequent conditioning whereby the adhesive is somewhat softened, for example, by heating. The further treatment may also advantageously include subjecting the material while in the conditioned state to mechanical vibration. The conditioning of the material by softening the adhesive after the depositing of the fibers, causes the fibers to be more firmly gripped by the adhesive and this effect is furthered by a concomitant vibration.

The method and apparatus of the invention will be more particularly described with reference to the illustrative embodiments shown in the accompanying drawings in which

Fig. 1 illustrates one form of method and apparatus embodying the principles of the invention; and

Fig. 2 represents a modified form of the invention.

In Fig. 1, 10 represents a high potential electrode and 11 a grounded electrode. The electrodes are supplied with unidirectional high potential current by means of mechanical rectifier 12. Electrode 11 comprises a plurality of fixed bars 21, preferably curved on their upper sides, and a number of movable striking bars 22 carried on rocker arm 13. Arm 13 is rocked about pivot 14 by means of lever arm 23 and armature 24 of electromagnets 15 which are energized in alternation by means of reversing switches 16 operated by extension 25 on lever arm 23.

A web A, for example, of fabric material, is passed over roller 17, where it is coated with adhesive from container 18 by means of dip roll 19. Suitable fibrous material, such as rayon flock, is shown in predetermined amount on the adhesive-coated surface of the web by means of the rotating sifter 20. The web carrying the fibers on its adhesive-coated surface is then passed between electrodes 10 and 11, although lower electrode 11 where it is subjected to the combined effects of the strong electrical field between the electrodes and the vibration of rapper 13. The combined action of the electrical and mechanical forces causes the flock to be vertical endwise into the adhesive. The electrical field tends to orient the fibers in a direction perpendicular to the field and at the same time cooperates with the vibration in tending to force the flock further into the adhesive, while the vibration tends to make the fibers more responsive to the orienting effect of the electrical field.

In Fig. 2, 30 is a high potential electrode corresponding, as shown in connection with electrode 10 in Fig. 1, while 31 is a grounded electrode provided with vibrator mechanism, for example, of the type shown in connection with electrode 11 in Fig. 1.

Web A is led from roll 32 under center 33 which provides a coating of adhesive on the upper surface of the web, and then under sifter 34 as

[fol. 714]

which sprinkles a desired quantity of flock on the web. The web then passes between electrodes 30 and 31, where it is subjected to the combined effects of a high potential electrical field and mechanical vibration as in Fig. 1.

The pile-surfaced web is then passed under a vibrator 36 which may be of the same type as shown in connection with electrode 11 in Fig. 1, where excess fiber is shaken off and falls into hopper 38. The web is then led into heater 37 wherein the adhesive is softened. While the adhesive is in the softened condition it is subjected to further vibration by vibrator 36 in order to more firmly position the fibers in the adhesive. The web is then subjected to conditions for finally indurating the adhesive, for example, by means of drier 39, and the finished material is rolled up on roll 40.

The adhesive used in the practice of the invention should be sufficiently viscous to avoid a tendency to pull off or string in the electrical field, and also to prevent the fibers laid thereon from penetrating too far into the adhesive prior to passage into the electrical field. The adhesive may well be more viscous than when electrical forces alone are used for the deposition as the combination of mechanical and electrical forces will force the fibers into a more viscous adhesive.

The method and apparatus of the invention are particularly valuable for the deposition of fibers of short length and for operating under conditions such that the fibers have very low conductivity. The method is very flexible as to conditions of operation, type and size of fiber, character of adhesive, nature of base material and the like and permits of a wide variation in these and other factors.

I claim:

1. A method of making pile surfaces comprising forming a mat of pile-forming fibers on an adhesive-coated surface and then subjecting the surface and the pile-forming fibers to the conjoint action of a strong electrical field and mechanical vibration and thereafter softening the adhesive temporarily and subjecting the material to mechanical vibration while the adhesive is in softened condition.

2. In the production of pile-surfaced materials by the deposition of pile-forming fibers upon an adhesive-coated surface, the improvement which comprises subjecting the adhesive having pile-forming fibers imbedded therein to softening conditions and mechanically vibrating the material while the adhesive is in softened condition.

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[fol. 715]

Nov. 19, 1940. A. F. MESTON 2,222,539

METHOD OF AND APPARATUS FOR MAKING PILE SURFACED SHEETS

Filed Dec 11, 1934 2 Sheets-Sheet 1

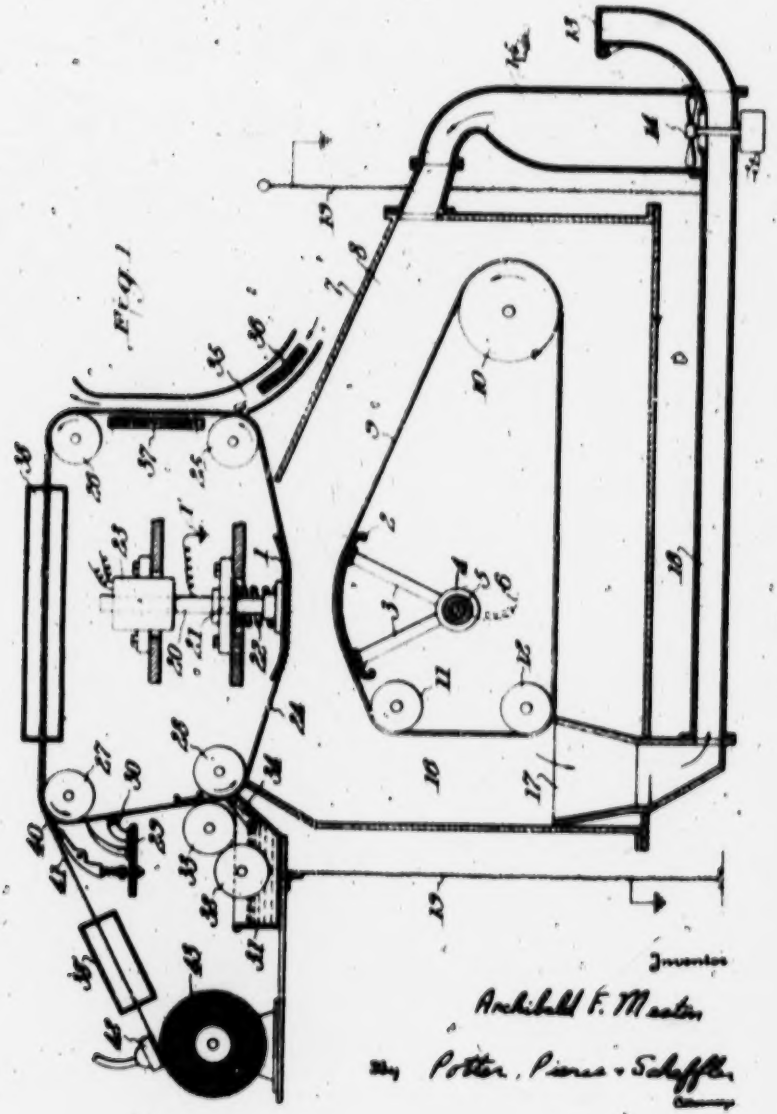

Fig. 1

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[fol. 716]

Nov. 19, 1940. A. F. MESTON 2,222,539

METHOD OF AND APPARATUS FOR MAKING PILE SURFACED SHEETS

Filed Dec. 11, 1934 2 Sheets-Sheet 1

Fig. 2.

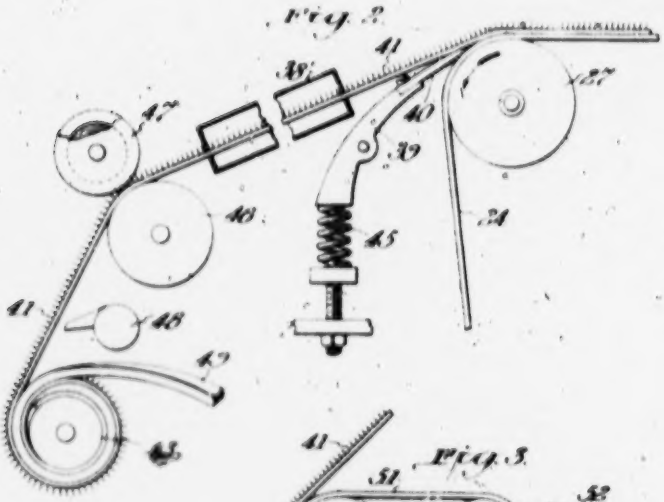

Fig. 3.

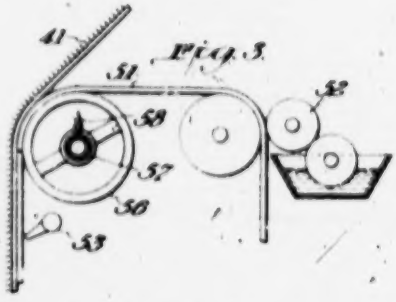

Fig. 4.

Fig. 5.

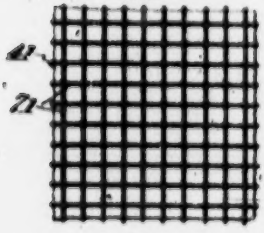

Fig. 6.

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Attorneys

Patented Nov. 19, 1940

2,222,539

UNITED STATES PATENT OFFICE

2,222,539

METHOD OF AND APPARATUS FOR MAKING PILE-SURFACED SHEETS

Archibald F. Morton, Middlesex, N. J., assignor, by mesne assignments, to Bakelite-Macnaughton Corporation, a corporation of Massachusetts

Application December 11, 1934, Serial No. 757,928

15 Claims. (Cl. 154—2)

This invention relates to material in sheet form characterized by having particles of small size integrally associated with a surface of the material. More in particular the invention has to do with a sheet comprised of relatively thin, flexible material and a simulated pile of attenuated fibers integrally attached to the flexible material, and a method of making the piled sheet.

Apparatus and methods have been invented for producing simulated pile fabrics wherein an adhesive covered surface is placed in an electric field and attenuated fibers such as rayon flocks are carried into the electric field and electrically deposited in oriented position on the adhesive covered surface. Heretofore, in making simulated piled fabric materials, the adhesive is spread over a base of fabric, paper or other material and this base becomes a constituent of the products. Products thus formed and constituted have proven too heavy or stiff for some of the purposes for which they have been intended. The addition of a base element to the product has added appreciably to the cost, also.

In the present invention, the adhesive is spread over the surface of a base member only during periods of attaching the fibers and drying and/or toughening the adhesive. The dried adhesive is then removed from the base member as a thin sheet with fibers attached, as a pile, on a surface of the sheet. The base member is again coated with adhesive for making additional product. Adhesives with different characteristics can be variously applied to the base surface and the products will differ correspondingly as to weight, flexibility, transparency and other properties. The preferred product is a thin, flexible, sheet of appreciable tensile strength which is piled with the density of fibers desired and which can be readily attached to surfaces with well known adhesives.

An object of the invention is to produce material as a homogeneous or integral sheet with a piled surface, and having the valuable decorative and constructive properties of velvet type fabrics.

Another object is to produce a thin, tough, flexible sheet with a piled surface which can be attached by adhesives or otherwise to the surfaces of walls and other objects for the purpose of decorating the surfaces.

Another object is to produce, at low cost, a piled surface with a very light backing that can be attached to simple fabrics and similar materials thereby giving such materials a rich appearance, added strength, and other desirable properties without adding greatly to the weight or cost of the materials or appreciably decreasing their flexibility.

Still another object is to produce a thin water proof and water tight sheet material that simulates fabrics in appearance and/or other physical properties.

A further object is to provide a method for forming a sheet product of the type described, stripping the sheet material from the surface upon which it was made and immediately attaching it to another surface.

The apparatus and procedure used in realizing the above mentioned and other objects will be more particularly described with reference to the accompanying partially diagrammatic drawings in which:

Fig. 1 is a side view, in section, elevation, of apparatus for carrying out the method and making the product of the invention;

Fig. 2 is a side elevational view of apparatus for stripping the product from the carrier surface upon which it is formed and preparing it for storage;

Fig. 3 is a side view, in elevation, of apparatus for applying the product as a coating immediately after it is stripped from the carrier surface;

Fig. 4 is a perspective view of a fragmentary portion of the product to illustrate the deposition of the particles comprising the pile;

Fig. 5 is a plan view of the back of a portion of the product when reinforced by open mesh fabric; and

Fig. 6 is a side view of the object shown in Fig. 5.

In Fig. 1, member 1 is an electrode, grounded at 1', upon which terminate the lines of force of the electric field that deposits the fibers constituting the pile of the product. The opposing or complementary electrode upon which the other end of the field terminates is shown at 2. Electrode 2 is supported by members 3, 4 and 5 and insulating members, not shown, so that it can be maintained at high potential, with respect to ground, when connected to a source of high potential power by means of conductor 6. The just described assembly is positioned in any enclosure or casing 7, preferably made, at least in part, of transparent insulating material such as glass. The horizontal supporting member 5, suitably insulated, passes through wall 8 of casing 7 and one end of member 5 is connected to a source of high potential power as diagrammatically indicated at 9.

An endless belt 9 passing over electrode 2, and further positioned by pulleys 10, 11 and 12, is used

to move the attenuated particles for forming the pile of the product into the electrical field.

The flocks or other particles are introduced at controlled opening 13 and are blown by fan 14 through passage 15 into the space above pulley 10. Most of the particles fall on belt 9 but some may be carried into the electric field in suspension in the gas stream which is kept in motion by fan 14, especially if the gas velocity set up by the fan is high. The particles are lifted from belt 9 when under electrode 1 by the electric forces acting between electrodes 1 and 2. Particles which are not lifted from belt 9 or which fall back on the belt are carried over to passage 16 and fall into hopper 17 from whence they are returned by the gas stream flowing in passages 15 and 15 set up by fan 14 to be again subjected to the electric forces. A protective grounded screen 19 may be placed around the high potential parts of the apparatus.

Electrode 1 is mounted on rod 20 which is guided and positioned by bearing 21 and solenoid member 23. A spring 22 holds the electrode down on movable carrier 24 thus tensioning the latter. Solenoid 23 periodically reciprocates rod 20 to give a hammer motion to electrode 1 and bring about a jarring of belt 24. Belt 24 is the carrier upon which the product is formed. It is preferably an endless belt of conducting material, although it need not be, and is held in position and moved by pulleys 25, 26, 27 and 28. When of metal or other electrically conducting material, the face of the carrier is, of course, at the same potential as electrode 1 over which it passes and really constitutes the electrode upon which the lines of force terminate. It is convenient, however, to call member 1 the electrode and refer to member 24 as a surface positioned adjacent the electrode.

Preparatory to coating the carrier with the adhesive that comprises the product the carrier is cleaned of adhering matter by scraper 29 and moved under applicator 30 to receive a lubricant or other separating coating to make the separation or stripping steps, to be later described, easy of accomplishment.

Basin 31 holds the material, commonly an air drying plastic with the properties of an adhesive, that comprises an important part of the product and rolls 32 and 33 apply this material to carrier 24 in the manner well known in the coating art. Doctor knife 34 is set to control the final depth of material before it enters the electric field between electrodes 1 and 2 for deposition of pile. Heater 37 applies heat to the coated carrier from the back of the carrier and chamber 38 directs air heated by element 39 across the face of the product thereby evaporating and carrying off solvents from the adhesive material. Chamber 38 is another heating or conditioning device for further drying, polymerizing or otherwise toughening the piled coating on carrier 24. At roll 27, a separating knife 40 separates the product from the surface of carrier 24. The separated product as indicated at 41 is assembled as a roll 42 or otherwise disposed of, but it has been found advantageous before storing or using the product to gently agitate and brush it of poorly attached fibers. A vacuum cleaner unit as indicated at 43 is very useful for this purpose.

Where the stripped off product 41 is to be applied immediately to a surface in the manner illustrated in Fig. 3, for instance, the under surface (not piled) can be left slightly moist and sticky; but where the product is to be rolled or stacked upon itself for later use, the under surface that has just been exposed by separator 40 is preferably dried further by drier 38'.

In Fig. 3, edge 40 is for assuring the separation of product 41 from carrier 24 as the latter turns on pulley 27. Edge 40 is preferably a flexible member that extends across the face of carrier 24 and is supported against the surface of the carrier by a plurality of lever means 36, only one of which is indicated, a spring 46 exerting a controllable pressure on each lever 36. A drying chamber 38' to supplement drier 38 has been found useful and sometimes necessary when the adhesive contains slow drying plasticizers. The under (unpiled) side of the product is seldom dried sufficiently when it is separated from carrier belt 24 especially if the latter is impervious and does not permit solvent vapors to pass from the product through the belt. Drier 38' is adapted to dry the newly exposed under side of the product. The unpiled surface may be dusted with soapstone, bentonite dust, starch, or some other powdered material as a precaution against this surface retaining a sticky condition and means 48 comprises a duster for this purpose.

Referring further to Fig. 2, rolls 46 and 47 are provided in order that the product may be pulled evenly from the carrier belt 24 as shown. Pulley 46 has a flat surface that contacts the product 41 over its entire width but pulley 47 is cut away between the ends so that only the selvages are gripped between rolls 47 and 46 and the fibers of the pile can extend up into the recess in pulley 47 in upright position. Ordinarily the surface contact of pulley 46 is sufficient to provide the necessary tension in strip 41 but if the product does slip on pulley 46, pulley 47 is pressed down upon the selvages of the material to provide a positive grip thereon. The finished product is wound upon itself as shown at 43, spacing strips 49 being preferably wound into the roll at the selvages to prevent crushing of the pile. The several pulleys and rolls comprising the apparatus, especially members 27, 46 and 43 are turned in proper relationship in the manner known in the coating and other processing arts so that the tension in the various belts and strips is suitable for carrying out the method herein described.

Fig. 3 illustrates apparatus that has been found useful in attaching the product immediately after it is formed to sheet surfaces. The product shown as a piled sheet 41 immediately after it is stripped from carrier 24 as shown in Figs. 1 and 2 is connected with another sheet indicated at 51. When necessary, the sheet to be coated with product 41 is spread with adhesive, applicator 52 being used for the purpose, but I have found that the product can be removed from carrier 24 with the under side retaining a tacky, adhesive character and that it can be attached to other surfaces without additional adhesive. Especially good results are obtained when sheet 51 is run over a heated pulley while being pressed against sheet 41. Pulley 53 utilizes a perforated pipe 57 as a shaft, the hollow shaft functioning as a gas burner with many small jets 58. Extended space for air cooling need not be provided if means such as air jets 59 are used to cool the composite product leaving heated pulley 53. Very good results are obtained with thermo-plastic adhesives with this embodiment of the invention; and with an extension of the heating period, rubber cements are satisfactorily vulcanized in this manner.

The step just described has been found of great value in coating open work fabrics. To di-

rectly coat a fabric with a pile in the manner heretofore described, it is usually necessary to surface coat the fabric with a filler before the adhesive that is to hold the pile is applied. If this is not done, a very great amount of adhesive is taken up by the fabric and the resulting product is apt to be heavy, stiff and expensive. With the present invention, the pile is first incorporated into a thin, flexible, relatively inexpensive base and this product in dried or semi-dried condition is applied directly to the fabric to be given a piled surface, for instance, to a woolen cloth to be used in the manufacture of rain coats.

A particular characteristic of the product of the invention is the strength given the adhesive upon drying by the flock or other fibers used in forming the desired pile. In Fig. 4, a portion of product 41 is shown in an exaggerated manner. The adhesive is represented at 42, fibers in reclining position are shown at 43 and upright fibers are shown at 44. It is difficult to make all the fibers deposited upon an adhesive covered surface by electrical means stand erect. The first fibers to touch the adhesive usually bend over and become embedded more or less lengthwise in the adhesive as indicated at 43. If the electric field is very strong and especially if a corona discharge is present, quite a few of the fibers lie flatwise on the surface of the adhesive while the first few are being deposited perpendicular to the surface as indicated at 44. The reclining fibers do not make for a satisfactory pile per se, but they do reinforce and strengthen the adhesive as it dries and make for a desirable product of the kind herein described. From about one to ten percent of the fibers recline, depending upon the strength of the electric field, and other more or less controllable conditions of deposition, and these fibers are well hidden by the erect fibers constituting the pile proper. So advantage is taken of the strengthening effect of the reclining fibers without incurring loss in the appearance of the product.

Reinforcing fibers may be separately deposited, either electrically or mechanically, on either side of the adhesive layer before electrically depositing the pile-forming flock, or reinforcing fibers may be added to the adhesive substance before it is formed into a layer, for example by admixing fibers with the adhesive in container 31.

Figs. 5 and 6 illustrate the product as reinforced in strength by having a net or open fabric 71 attached to the unpiled surface. The net adds but little to the cost and detracts but little from the flexibility of the product, but it does add appreciably to the strength of the sheet.

The reinforcing net may be associated with the adhesive layer, for example by feeding a web of net material between roll 33 and carrier 24 in the apparatus of Fig. 1, or it may be associated with the adhesive layer after stripping from carrier 24, similarly to the application of backing layer 51 in Fig. 3.

Two sheets of the product can be joined back to back giving a material having a pile on both surfaces. Walls can be "papered" with the sheeted material described and when made with stretchable material it can be pulled tightly over irregular surfaces while being applied. Where a surface can be maintained at constant potential, as grounded, the sheeted product can be applied to that surface by placing an electrode energized from a high voltage direct current source in front of the sheet. The sheet will take up a charge of electricity and be attracted to the surface to be covered. Many other uses and applications of the product of the invention will be obvious to those skilled in the art from the foregoing description of the invention.

The following is an illustrative example of the method of operation of this invention. Electrodes 1 and 2 are separated from 2½ to 4 inches and electrode 2 is connected to a source of unidirectional current at from 20 to 40 kilovolts, the voltage to be regulated so that there is no likelihood of sparking between the electrodes. Belt 24 of smooth brass which has been cleaned thoroughly is put in motion by pulleys 25 and 27, coated with a thin film of gelatine by applicator 30, then spread with coating wheel 33 with an adhesive made up of cellulose derivatives, plasticizers, and solvents (for example, a coating material used for forming artificial leather), and this is smoothed out by doctor knife 34 to a depth of .03 inch. The speed of belt 24 may be from 1 to 6 feet per minute depending on conditions and the mass of pile desired. Belt 9 is made to revolve at a speed several times faster than belt 24, fan 14 is started and rayon flocks approximately ¼ inch in length are introduced at 13. Heaters 36 and 37 are put in operation as is the blower, not shown, which forces air through duct 35. Heaters 38 and 38' are put in operation in due time as required. The other operations for completing the formation of the product are as previously described.

A wide range of adhesive substances may be used as the base of the pile-surfaced sheet of the invention; for example, compositions which harden by drying or evaporation, such as solutions of cellulose derivatives, natural and synthetic resins, and other plastic materials in organic or aqueous solvents; compositions which harden by the action of heat, such as those containing the heat reactive phenol-formaldehyde and glycerol-phthalic anhydride resins; compositions which harden by cooling, such as those containing vinyl resins; compositions which harden by absorption of oxygen, such as those containing air-drying oils; compositions which harden upon chemical treatment, such as viscose; and compositions which may be hardened by vulcanization, such as those containing rubber.

The terms "indurating" and "indurated" are used herein to denote broadly the various hardening, toughening, drying, setting or curing processes used in the arts.

I claim:

1. A method of making a sheet material having a piled surface which comprises forming a layer of an adhesive substance upon a supporting surface, electrically depositing attenuated particles in erect position on said layer, indurating said layer and stripping the layer from the supporting surface.

2. A method of making a sheet material which comprises forming a layer of a hardenable plastic composition upon a supporting surface, depositing attenuated particles on said layer by means of an electrical field, indurating said layer and stripping the layer from the supporting surface.

3. A method of making a sheet material which comprises forming a layer of a hardenable plastic composition upon a supporting surface, depositing attenuated particles on said layer by means of an electrical field, indurating said layer, stripping the layer from the supporting surface and

[fol. 720]

attaching said layer to a layer of backing material.

4. A method of making a sheet material which comprises forming a layer of a hardenable cellulosic composition upon a supporting surface, depositing attenuated particles on said layer by means of an electrical field, indurating said layer and stripping the layer from the supporting surface.

5. A method of making a sheet material which comprises forming a layer of a hardenable plastic composition upon a supporting surface, depositing textile fibers on said layer by means of an electrical field, indurating said layer and stripping the layer from the supporting surface.

6. A method of making a sheet material which comprises forming a layer of a hardenable cellulosic composition upon a supporting surface, depositing rayon flock on said layer by means of an electrical field, indurating said layer and stripping the layer from the supporting surface.

7. A method of making sheet material having a piled surface which comprises forming a layer of an adhesive substance upon a supporting surface, electrically depositing attenuated particles in erect position on said layer, indurating said layer sufficiently to permit stripping of said layer from said surface, stripping said layer from said surface and further indurating the layer.

8. A method of making a sheet material having a piled surface which comprises forming a layer of an adhesive substance upon a supporting surface, electrically depositing attenuated particles in erect position on said layer, indurating said layer sufficiently to permit stripping of said layer from said surface, stripping said layer from said surface, associating a reinforcing material with said layer and further indurating the product thus formed.

9. A method of making an extended strip of sheet material having a piled surface which comprises continuously forming a layer of an adhesive substance upon a supporting surface, electrically depositing attenuated particles in erect position on said layer, indurating said layer and removing the layer from the supporting surface in a continuous strip of extended length.

10. A method of making an extended strip of sheet material having a piled surface which comprises continuously forming a layer of a hardenable plastic composition upon a supporting surface, electrically depositing attenuated particles in erect position on said layer, indurating said layer and removing the layer from the supporting surface in a continuous strip of extended length.

11. A method of making a sheet material having a piled surface which comprises forming a layer of an adhesive substance upon a movable supporting surface, passing said surface through an electrical field while supplying pile-forming fibers into said field, indurating the adhesive layer and stripping the indurated layer from the supporting surface.

12. Apparatus for making sheet material having a pile surface, comprising a pair of opposed electrode members, means for maintaining an electrical field between said electrode members, supporting surface members movable through said electrical field adjacent each of said electrode members, means for supplying a layer of adhesive composition upon one of said supporting surface members, means for moving both of said supporting surface members through said electrical field and means for supplying pile-forming materials to said electrical field.

13. Apparatus for making sheet material having a pile surface, comprising a pair of opposed electrode members, means for maintaining an electrical field between said electrode members, supporting surface members movable through said electrical field adjacent each of said electrode members, means for applying a layer of adhesive composition to one of said supporting surface members before it passes into the electrical field, means for indurating said adhesive layer after it leaves the electrical field, means for stripping the indurated adhesive layer from the supporting member, and means for supplying pile-forming materials to the electrical field.

14. Apparatus for making sheet material having a pile surface, comprising a pair of opposed electrode members, means for maintaining an electrical field between said electrode members, supporting surface members movable through said electrical field adjacent each of said electrode members, means for applying a layer of adhesive composition to one of said supporting surface members before it passes into the electrical field, means for indurating said adhesive layer after it leaves the electrical field, means for stripping the indurated adhesive layer from the supporting member, means for further indurating said adhesive layer after stripping, and means for supplying pile-forming materials to the electrical field.

15. A method of making an extended strip of sheet material having a piled surface which comprises continuously forming a layer of an adhesive substance upon a supporting surface, electrically depositing reinforcing fibers upon said layer, electrically depositing pile-forming fibers in erect position on said layer, indurating said layer and removing the layer from the supporting surface in a continuous strip of extended length.

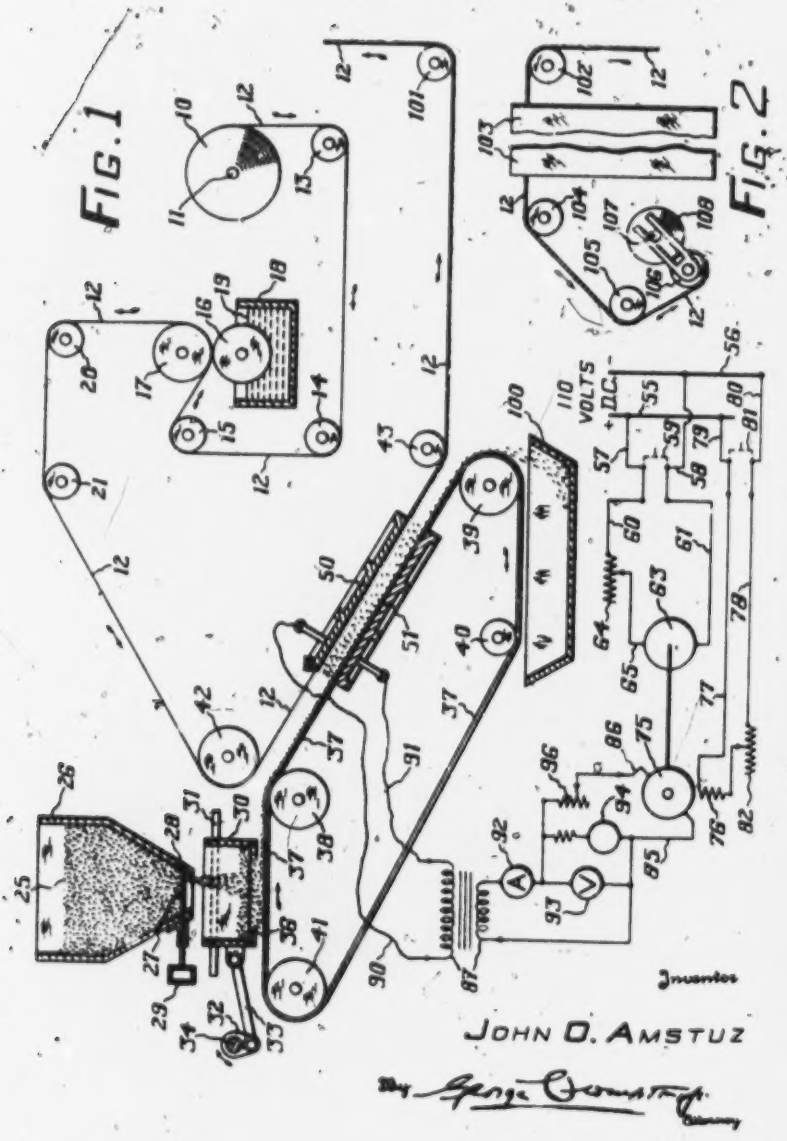
ARCHIBALD P. MESTON.

[fol. 721]

Dec. 3, 1940. J. O. AMSTUZ 2,223,476

METHOD FOR MAKING PILE FABRIC

Filed Nov. 2, 1936 2 Sheets-Sheet 1



Inventor

JOHN O. AMSTUZ

By George Amstutz

[fol. 722]

Dec. 3, 1940. J. O. AMSTUZ 2,223,476

METHOD FOR MAKING PILE FABRIC

Filed Nov. 2, 1938 2 Sheets-Sheet 2

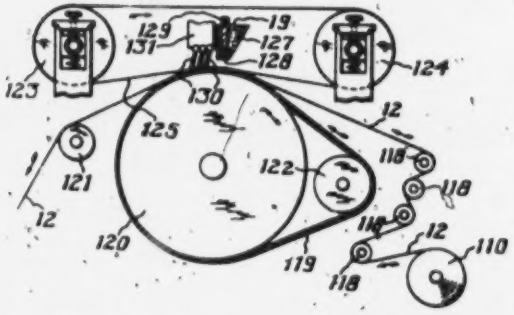


FIG. 5

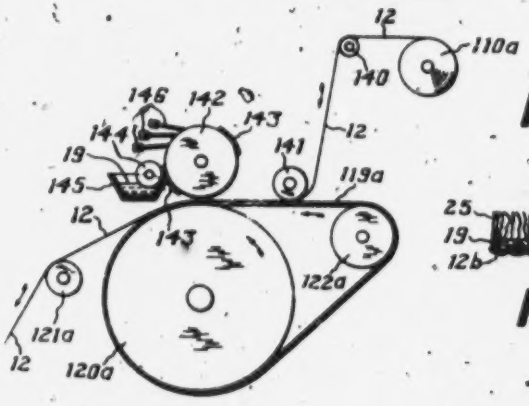


FIG. 6

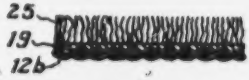


FIG. 4

FIG. 3

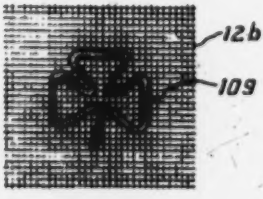


FIG. 7

Inventor

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By George Gomarsky

[fol. 723]

Patented Dec. 3, 1940

2,223,476

UNITED STATES PATENT OFFICE

2,223,476

METHOD FOR MAKING PILE FABRIC

John O. Amptan, Troy, N. Y.

Application November 2, 1936, Serial No. 108,704

12 Claims. (Cl. 91—68)

The invention relates to the manufacture of pile fabric.

One object of the invention is to provide a new type of pile fabric which can be produced at low cost. Another object of the invention is to form a pile fabric with a paper backing. Another object of the invention is to provide a rapid method for the manufacture of a pile fabric in an unlimited number of designs. Another object of the invention is to deposit flock upon a sheet surface in a fine coating with the fibres arranged in parallelism. Another object of the invention is to provide a textile article coated with flock in which the fibres are laid normal to the plane of the textile material. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings illustrating the mechanical features of this invention,

Figure 1 is a diagrammatic view illustrating apparatus for the manufacture of a pile fabric in which the pile is continuous and attached to a backing of paper or cloth.

Figure 2 is the representation of a drying room and take-up device.

Figure 3 is a greatly magnified cross sectional view of a sheet of the pile fabric constructed in accordance with the invention in which the backing is paper.

Figure 4 is a view similar to Figure 3 illustrating a pile fabric of the invention in which the backing is cloth.

Figure 5 is a diagrammatic view of stenciling apparatus which may be substituted for the adhesive coating apparatus of Figure 1 in order to put the pile on to the fabric in the form of a design.

Figure 6 is a diagrammatic view of printing apparatus utilizing an engraved roll which may be substituted for the apparatus of Figure 5 or the adhesive applying apparatus of Figure 1.

Figure 7 is an illustration of a pile fabric incorporating a design manufactured according to the invention.

Referring first to Figure 1, I provide a roll of sheet material 10. This may be paper or it may be cloth. If cloth is used preferably a fairly close weave will be employed but I may use a relatively inexpensive grade of cloth. Cotton sheeting is a good example of the cloth that may be employed and desirably is dyed the same color as that of the pile that is to be applied.

The roll of sheet material 10 is wound on a roller 11 which is mounted in any suitable manner as is well known in the textile finishing art and a suitable friction brake may be applied if desired. The sheet material 12 passes down around a roller 13 and up around a roller 14 and around a roller 15. It then passes between an adhesive applying roller 16 and a pressure roller 17. The roller 16 revolves in a trough 18 filled with adhesive 19 and suitable apparatus may be provided for heating the adhesive. The sheet material 12 then passes upwardly to a roller 20 then over a roller 21 whence it is delivered to that portion of the apparatus which applies the pile. Some or all of the rollers 13, 14, 15, 16, 17, 20, and 21 are positively rotated and preferably all of them are rotated in synchronized relation at a given peripheral velocity, but the drive means for the rollers has not been illustrated as such is well understood.

Any suitable adhesive 19 may be used. As an illustrative example I mention the various glues. I may use a printing glue, for example the relatively flexible glue described in Dickinson Patent No. 982,896 or a glue which is particularly suitable for textile printing such as described in Mills Patent No. 969,113. For certain purposes and to achieve certain results I may tan the glue with formaldehyde in order to resist the action of water. In mentioning glue as the adhesive I wish it to be understood that the invention is not limited to the use thereof and in mentioning particular types of glue it should be understood that I may use other types, the examples given being merely examples of practical ways to carry out the invention.

I provide a quantity of flock 22 which I may place in a hopper 24. The term flock is usually applied to the shearings from woolen cloth produced in the finishing mill. These shearings comprise separated fibres of substantially uniform length. Preferably I use fibres of as uniform length as possible, but I may use fibres of materials other than wool, for example fibres of silk, cotton, or rayon.

The hopper 24 has a suitable sliding gate 27 controlling the bottom opening 28 thereof and the gate has a handle 29 by means of which the operator can cause flock to be delivered as desired.

[fol. 724]

I find that better results are achieved if the flock is well broken up prior to the application thereof, as will be described. Furthermore, it should preferably be fairly well distributed laterally of the machine. I therefore provide a box 29 to receive the flock from the hopper 26, the box being mounted on slideways 31 to move rectilineally and a crank 32 and pitman 33 being provided to vibrate the box 29. The crank 32 is mounted on a suitable shaft 34 driven from any suitable source of power at a speed of for example 400 R. P. M. In the bottom of the box 29 is a screen 36 through which the flock passes on to a traveling belt 37.

The traveling belt 37 is preferably slightly wider than the sheet material 12 and travels at a variable speed, being driven by a variable speed motor, not shown. The belt 37 passes around rollers 38, 39, 40, and 41, one of which is positively driven by the variable speed motor. The purpose of varying the speed of the belt is to find for each different condition by quick empiricism the best speed to deliver the right amount of flock to the apparatus. The speed range should be both above and below that of the sheet material 12. The belt speed is varied in connection with the gate opening 28 and the particular mesh of the screen 36. Various modifications of the means to deliver flock may be adopted, for example an electric vibrator with rheostat control may be substituted for the crank 32 and pitman 33 and it is also desirable to provide an electric or pneumatic vibrator to vibrate the hopper 26 to eliminate packing of flock in the hopper itself. Electric and pneumatic vibrators are now well known and are regular commercial products which can be procured in a variety of sizes. Conditions vary widely with particular specifications of the ultimate fabric that is being produced but with variable controls such as have been described, only a few minutes' variation of the adjustments herein described will readily determine the correct setting for all thereof in a given apparatus.

Preferably the belt 37 passes downwardly between the rollers 39 and 40 at an incline determined by the following considerations: It is desired that sheet material 12, which after leaving the roller 41 passes between rollers 42 and 43 in a course parallel to that of the belt 37, shall sag as little as possible. The vertical condition is the condition of least sag. On the other hand, it is not desired that the flock shall move on the belt 37 by reason of the force of gravity. The limiting factor here is the point where the coefficient of friction of the flock is equal to its component along the downward path due to gravity. Satisfactory results can be achieved with a pitch about as shown in Figure 1 and somewhat steeper inclinations may be employed.

I provide an upper electrode 50 and a lower electrode 51. These may be made of metal, for example of aluminum for lightness, and may be of ribbed construction as shown, for the same reason. They may be covered with insulating material, such as resinoid or hard rubber, which is an advantage if the coating is done with higher voltages or when the flock is too conductive and may facilitate the forming or sustaining of an arc between the electrodes. The surfaces of the electrodes 50 and 51 that face each other are plane surfaces and preferably as nearly as possible they are in contact respectively with the back side of the sheet material 12 and the under side of the belt 37. The belt 37 is preferably fairly thin and may be made of a suitable grade of denim cotton cloth so that the flock will be very close to the electrode 51.

For energizing the electrodes 50 and 51 to produce an electrostatic field between them, I provide high voltage alternating current variable frequency apparatus which may be as in the following illustrative example:

Still referring to Figure 1, I provide any suitable source of direct current connected to main power lines 56, 56. The voltage may be as desired, for example 110 volts. The conductor mains 56, 56 are connected by conductors 57 and 58 and a knife switch 59 to conductors 60 and 61. The conductor 61 leads to a terminal of a D. C. motor 63. The conductor 60 is connected to a rheostat 64 which is in turn connected by means of a conductor 65 to the other terminal of the motor 63. The motor 63 may be series or shunt wound, as desired, and the rheostat 64 may be in the outside conductor or may be in the shunt circuit for the field winding, as desired, or any other suitable variation may be adopted. The motor 63 is therefore a variable speed motor and for it may be substituted any other variable drive subject to control by fine increments of speed change, for example any form of variable speed friction gear drive apparatus may be used, many types thereof being now well known.

The motor 63 is coupled to a single phase A. C. generator 70. The field 76 of the generator 70 may be excited by current from the D. C. line 56, 56, conductors 77, 78, 79, 80, and a knife switch 81 being provided for this purpose. I preferably provide a further rheostat 82 for controlling the voltage of the generator 70.

The conductors 99, 99 from the generator 70 are connected to the primary of a step-up transformer 87. The secondary of the transformer 87 is connected by conductors 88 and 91 to the electrodes 50 and 51 respectively. In the conductor line 88 is preferably located an ammeter 92 and across the conductors 88 and 88 is preferably connected a volt meter 93. I further provide connected between the conductors 88 and 88 a frequency or cycle meter 94. Furthermore, in circuit in the conductor 88 I place a rheostat 98.

I am enabled by this apparatus to achieve a voltage across the electrodes 50 and 51 of the order of one hundred thousand volts which I can vary between five thousand volts and one hundred thousand volts. The gap between the belt 37 and the sheet material 12 may be varied but I have found that a gap of one inch to two inches works well in actual practice. By driving the motor 63 at varying speeds of rotation between 600 R. P. M. and 1800 R. P. M., I am enabled to change the frequency between ten cycles and thirty cycles, using a generator 70 which is the equivalent of a two-pole generator.

I have discovered that comminuted textile material such as flock may be separated and oriented by means of an alternating current electrostatic field of high voltage of a given frequency for certain given conditions involving the gap distance of the field, the voltage strength, and the particular type of flock employed. When the electrodes 50 and 51 are impressed with opposite sign voltages, the flock simply bridges the gap between the sheet material 12 and the belt 37 in string formation and produces a short circuit and is ineffective for coating the sheet material 12. When the sign of each electrode changes with a frequency of the order indicated, the flock

lends to depart with the alternations of the current. Each of a given particle size has a natural frequency between electrodes spaced by a given gap. By adjusting the electric frequency to correspond with the fleck frequency, the fleck particles are broken up and prevented from producing sizing formation. As the frequency of the electric current nears the frequency of the fleck, the fleck is raised higher and higher until a regular sheet of fleck between the electrodes is produced. In other words, the propulsive impulses of the alternating current in opposite directions tend to project the fleck first lowest and then from the adhesively coated backing material, as the direction of current flow and the potential in the field alternate. Under the influence of a particular voltage in the field, it takes a particular fleck particle a predetermined length of time to move across the field, from a plane adjacent the lower electrode to the plane of the adhesively coated sheet, depending upon the characteristics of the fleck and, of course, the space between the electrodes. Fleck reaching the surface 12 which has been, as described, coated with glue or other adhesive, is retained there. All particles of fleck orient themselves normal to the surface of the material 12 and the result is a depositing of pile upon the material 12 in evenly spaced condition. If the fleck particles are not retained after they are projected toward the adhesive by a propulsive impulse in one direction, they will be projected away from the adhesively coated sheet during the other half of the alternating current cycle, whereupon their direction of movement will immediately be reversed, during the next cycle and they will be again projected toward the sheet. As stated above, the frequency of the alternating current cycle is adjusted to correspond to the frequency of movement of the fleck material so that the current impulses in opposite directions last for the correct duration of time to cause the particles to fluctuate back and forth between the belt 27 and the sheet material 12. The expression "frequency of commingled material" in the claims means the natural characteristics of the material under the influences referred to above.

If the delivery of fleck from the screen 30 is of the right amount, substantially all of it will be deposited upon the sheet material 12. Excess fleck over a certain amount simply drops back as it finds no more adhesive to attach to. Preferably more fleck is delivered than is needed so there will be certain to be enough and the excess falls into a collecting pan 103.

From the roller 63 the now sectioned material passes to a roller 101 whereon it is directed upwardly around a roller 102 into a drying room 103 where the material may be festooned then out around a roller 104 and roller 105 to a constant speed take up roller 106 by means of which it is wound on a roll 107 of the self-winding variety. The roller 106 is positively driven and preferably so also are the rollers 101, 102 and 104. The drying room 103 and the apparatus shown in Figure 3 may be located on a floor above the apparatus shown in Figure 1. By the particular arrangement of apparatus shown I avoid touching the coated side of the material with anything until it is ultimately wound into the roll of finished material 106 but even this may be dispensed with as the material may be cut off into sheets as it is delivered.

Considering now the product formed, Figures 3 and 4 respectively illustrate it, Figure 3 showing the pile fabric of the invention with a paper back 11a and Figure 4 showing the pile fabric of the invention with a cloth back 11b. In each case a layer of adhesive 10 unites the individual fibres of fleck or other material 26 to the backing 11a and 11b respectively. It will be noted that the fibres of material 26 stand parallel to each other and normal to the backing and this result is achieved in actual practice with the use of the apparatus described. The individual fibres of material 26 have like charges of electricity and so repel each other which is why they stand parallel to each other and the repulsion also spaces them evenly on the backing. Although I have particularly mentioned fleck, other comminuted fibrous material may be employed, for example rabbit's fur such as is used in the manufacture of hats.

The article of the invention elucidates felted cloth and with a paper backing may be used for decorative purposes where permanency and durability are not important qualities. For example it may be effectively employed as a table covering in restaurants and the like intended to be discarded after a single use. When embodied in material having a cloth backing 11b it rubs bearing more readily and has a somewhat more permanent character especially if formaldehyde has been used to tan the glue. It then may be used for many decorative purposes and as a substitute for woven pile fabrics. Either form can be used for wall paper or the like.

The apparatus already described produces a pile fabric with a composition or solid coating. It may be desired to omit the paper or cloth with fibres according to the invention in the form of a design. As shown in Figure 7 I may produce a textile fabric comprising a backing 120 with figures 122 of pile fabric formation and in any desired design. Such material may be used for a wide variety of purposes, in fact wherever cloth is used, as the design may be small or large and cover a small or a large area and the backing 120 may be previously printed if desired.

Two modifications for applying the pile in the form of a design are illustrated in Figures 5 and 6. Referring first to Figure 6, I have illustrated a stencilling apparatus of the general type disclosed in patent to Huntington No. 1,546,634. I provide a roll 110 of paper or cloth 11 which is conducted around small rollers 110 and then over a blanket 112 and a drum 120 to a roller 121 whereat it is delivered to the roller 63 and the rest of the apparatus shown in Figure 1. The blanket 112 extends also around a roller 122 as shown. Between rollers 121 and 124 suitably journalled as shown and as also described in the patent to Huntington referred to, extends a stencil 123. The stencil 123 may be of the type described in the patent to Huntington referred to or may be of other well known varieties, for example it may be of sheet metal with openings therein in the form of a design. The patent to Huntington referred to describes a stencil which is of open mesh material with many of the meshes blocked off or filled. The advantage of this particular stencil is, that a design in the form of a closed design without any break may be achieved.

The stencilling apparatus may further include a container 127 for adhesive 10 which extends therein, near the width of the machine and which container has a restricted opening 130 in the bottom thereof and a slide 131 arranged for controlling the flow of adhesive. Three pressers 132 are provided and held by a member 131 which is

supported by the machine. These pressers otherwise known as doctor scrapers may be made of brass or steel or rubber and they act to force the adhesive through the openings in the stencil and at the same time prevent an excess of adhesive from being carried forward on the stencil.

Referring now to Figure 6, I may provide printing apparatus as therein illustrated. The roll 116a of paper or cloth 12 passes over a roller 140 and then downwardly under a roller 141 into contact with a blanket 118a which extends around a drum 120a and a roller 122a. An engraved printing roller 142 has an engraved surface 143. This may be a copper or steel engraving. In contact with the engraved surface 143 is a roller 144 revolving in a trough 145 containing the adhesive 19. Adhesive is transferred to surface 143 and a plurality of doctor blades 146 press the adhesive into the depressions and scrape it from the elevated surfaces. The adhesive is then transferred to the sheet 12 where the sheet passes between the surface 143 and the blanket 118a. The sheet 12 then passes over a roller 121a and thence to the roller 42 and the rest of the apparatus from that point on shown in Figure 1 and ultimately to the drying and take up apparatus of Figure 2.

Different types of designs will be respectively applied by the different types of apparatus herein illustrated as the stencil type is better adapted for coating where there are large areas of design 100 and the engraved roller apparatus is preferable where the designs 100 are relatively small in area. Other types of apparatus for coating sheet material 12 with adhesive in the form of a design whereby comminuted fibrous material may be applied thereto as hereinbefore disclosed may be used.

It will thus be seen that there has been provided by this invention a method and apparatus and an article in which the various objects hereinbefore set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. In the art of coating sheet material with fibrous comminuted material, the improvement which consists in feeding the sheet material and the comminuted material into an electrostatic field of alternating potential, and controlling the cycle of alternations to make the positive and negative fluctuations equal in duration and potential.

2. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the positive and negative fluctuations are equal in duration and potential, introducing adhesively coated sheet material into said field and introducing comminuted pile surface forming material into the field, whereby the comminuted material is propelled toward and from said surface until it becomes adhesively united thereto.

3. In the art of producing pile surface sheet material, the process which comprises establishing an alternating electrostatic field, controlling the cycle of alternations to make the positive and negative fluctuations equal in duration and potential, controlling the frequency of alternations between ten and thirty cycles per second, introducing adhesively coated sheet material into the field and introducing comminuted pile surface forming material into the field.

4. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the positive and negative fluctuations are equal in duration and potential, the frequency of said field being not less than ten cycles, and introducing adhesively coated sheet material and comminuted pile surface forming material into the field in spaced relation, whereby the comminuted material is propelled toward and from said surface until it becomes adhesively united thereto.

5. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the positive and negative fluctuations are equal in duration and potential, introducing adhesively coated sheet material and comminuted pile surface forming material into the field in spaced relation, whereby the comminuted material is propelled toward and from said surface until it becomes adhesively united thereto, and adjusting the frequency of alternations in said cycle to substantially correspond to the frequency of the comminuted material to effect maximum propulsion of the material toward and from the sheet.

6. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the current fluctuations in opposite directions are equal in duration and potential, introducing adhesively coated sheet material and comminuted pile surface forming material into the field in spaced relation, whereby said fluctuations in opposite directions tend to propel the material toward and from the sheet, and adjusting the cycle of fluctuations to correspond to the frequency of the material and time required to move the material through said space under the potential existing in the field.

7. In the art of producing pile surface sheet material, the process which comprises conducting an adhesively coated backing sheet between spaced electrodes, conducting comminuted pile surface forming material between said electrodes in spaced relation to the sheet, establishing between said electrodes an electrostatic field alternating in a cycle in which the current fluctuations in opposite directions are equal in duration and potential, thereby propelling the material in the field toward and from the backing sheet at a speed determined by the potential in the field, and adjusting the frequency of the cycle of alternations to make each propulsive impulse of each cycle substantially correspond in time to the time required to move a particle of material in one direction through the electrostatic field.

8. In the art of producing pile surface sheet material, the process which comprises conducting a backing sheet having its undersurface adhesively coated between spaced electrodes, conducting comminuted pile surface forming material between said electrodes in spaced relation below the sheet, establishing between said electrodes an electrostatic field alternating in a cycle in which

[fol. 727]

the current fluctuations in opposite directions are equal in duration and potential, thereby propelling the material upwardly and downwardly in the field toward and from the backing sheet at a speed determined by the potential in the field, and adjusting the frequency of the cycle of alternations to make each upwardly directed propulsive impulse of each cycle substantially correspond in time to the time required to lift a particle of material through said space to the adhesively coated backing sheet.

9. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the current fluctuations in opposite directions are equal in duration and potential, introducing adhesively coated sheet material and comminuted pile surface forming material into the field in spaced relation, whereby said fluctuations in opposite directions propel the material in the field toward and from the backing sheet at a speed determined by the potential in the field, and adjusting the frequency of the cycle of alternations and the potential of the fluctuations to make each propulsive impulse of each cycle correspond in potential and time to the propulsive force and time required to move an article of material through said space to said backing sheet.

10. In the art of producing pile surface sheet material, the process which comprises establishing an electrostatic field alternating in a cycle in which the current fluctuations in opposite directions are substantially equal in duration and potential, introducing adhesively coated sheet material and comminuted pile surface forming material into the field in spaced relation, whereby said fluctuations in opposite directions propel the material in the field toward and from the backing sheet at a speed determined by the potential in the field, and adjusting the potential in the field to make each propulsive impulse of each cycle have the force required to move a particle of material through said space to the backing sheet during the time in the cycle that said impulse is effective.

11. In the art of producing pile surface sheet material in continuous lengths, the process which comprises providing, between spaced upper and lower electrodes, an electrostatic field of alternating potential energized by alternating current, the duration and amplitude of the negative and positive impulses of which are substantially equal, introducing adhesive surface sheet material into said field adjacent the upper electrode with the adhesive facing downwardly, bringing comminuted pile surface forming material into the field adjacent the lower electrode and below said surface of the sheet material, and electrically propelling the comminuted material in a direction counter to gravity and into the adhesive, whereby a dense pile surface coating is obtained in which the long axes of the comminuted material are substantially perpendicular to the plane of the adhesive, and whereby the excess of comminuted material not embedded in the adhesive is readily removed from the pile coated surface.

12. In the art of producing pile surface sheet material, the process which comprises conducting an adhesively coated backing sheet between spaced electrodes with the coated surface facing downwardly, conducting comminuted pile surface forming material between said electrodes in spaced relation below said sheet, establishing between said electrodes an electrostatic field alternating in a cycle in which the current fluctuations in opposite directions are substantially equal in duration and potential, utilizing the fluctuations in one direction to propel the material in the field upwardly toward the backing sheet to produce a dense pile surface coating on the sheet in which the long axes of the comminuted material are substantially perpendicular to the plane of the adhesive, and utilizing the fluctuations in the opposite direction to remove the excess of comminuted material not embedded in the adhesive from the pile coated surface.

JOHN C. AMSTUZ.

CERTIFICATE OF CORRECTION.

Patent No. 2,223,476. December 3, 1940.

JOHN C. AMSTUZ.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 5, first column, line 40, claim 10, for the word "spaced" read --speed--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 4th day of February, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

[fol. 728]

Feb. 11, 1941. G. CROMPTON, JR 2,231,324

APPARATUS FOR AND METHOD OF MAKING HAT BATS

Filed May 4, 1938

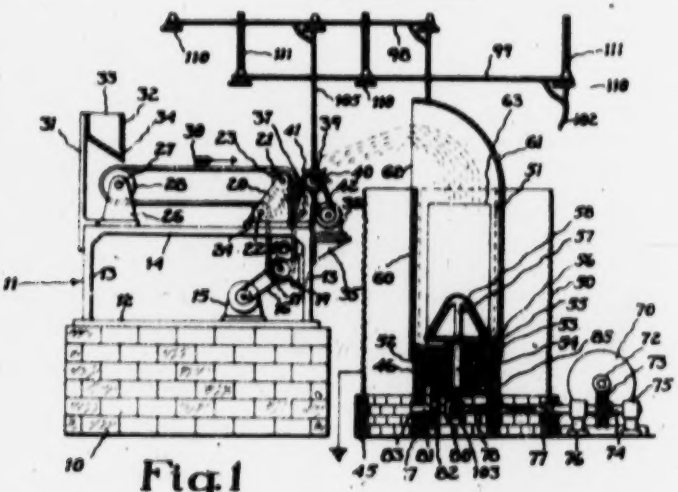

Fig. 1

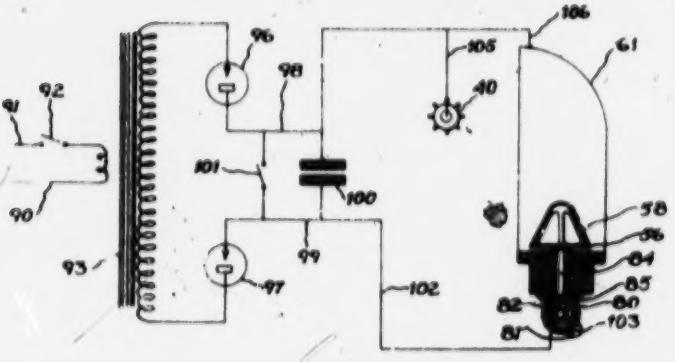

Fig. 2

Fig 3

Inventor

George Crompton Jr.

[fol. 729]

Patented Feb. 11, 1941

2,231,324

UNITED STATES PATENT OFFICE

2,231,324

APPARATUS FOR AND METHOD OF MAKING HAT BATS

George Crompton, Jr., Worcester, Mass., assignor to Hat-Blocking Corporation, Troy, N. Y., a corporation of Massachusetts

Application May 4, 1938, Serial No. 206,016

6 Claims. (Cl. 19—144)

The invention relates to apparatus for and a method of making hat bats.

One object of the invention is to provide a method of making hat bats which shall greatly reduce the time necessary to shrink the fur. Another object of the invention is to provide a method and apparatus greatly speeding up the production of bats. Another object of the invention is to make a superior felt. Another object of the invention is to standardize hat bodies so that the ultimate size of the hat with a given amount of fur and size of forming cone can be predicted with more certainty. Another object of the invention is to permit the use of a substantial amount of filler fur yet without any loss of time in the shrinking of the hat body. Another object of the invention is to standardize the shrinking of hat bodies. Another object of the invention is to permit the use of smaller forming cones. Another object of the invention is to reduce the amount of shrinking in the felting of the fur between the starting operation and the final sizing operation. Another object of the invention is to so form a hat bat that a smaller bat may be usable to make a given sized hat. Another object of the invention is to permit the use of shaped cones for the formation of hat bats. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation or order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing showing one of the many possible embodiments of the mechanical features of this invention—

Figure 1 is a view partly in side elevation and partly in vertical section showing an apparatus constructed in accordance with the invention.

Figure 2 is a wiring diagram.

Figure 3 is a side elevation of a forming cone of special shape which may be used in accordance with the present invention.

Referring first to Figure 1, I provide a base 10. This base 10 is preferably made of porcelain bricks put together without any mortar. As there are no great mechanical strains or stresses in the apparatus to be mounted on the base 10 the bricks may be merely laid together without any danger of the base falling to pieces.

Upon the base 10 I mount a cast iron frame 11 comprising a bottom portion 12, legs 13 and a table portion 14. On the bottom portion 12 is a slow speed electric motor 15 connected by a belt 16 to a roller 17 or a pulley connected thereto, the shaft 18 of the pulley and roller being journalled in a pair of brackets 19 attached to the legs 13.

A pair of glass brackets 20 support shaft 21 and 22 supporting rollers 23 and 24. The brackets 20 are attached to the table 14. A pair of brackets 26 also attached to the table 14 support a shaft 27 which supports a roller 28. A rubber conveyor belt 29 passes around the rollers 17, 23, 24 and 28 as shown. At the front of the machine is an upstanding bracket 31 holding a hopper 32 which has a large opening 33 at the top and a small opening 34 at the bottom which will direct fur onto the moving belt 29 which moves in the direction of the arrow.

I provide an angle bracket 36 on the right-hand end of the base 11 which supports a motor 38. Supported by the table 14 are a pair of glass plates 37. These glass plates 37 like the brackets 20 have insulated metal bearings, not shown, supporting a shaft 39 upon which is mounted a picker or wind roller 40 having the usual projections 41. This picker or wind roller 40 is made of metal and may be made of sheet metal, for example sheet aluminum so that it shall be light, and the projections 41 which extend longitudinally of the roller, as usual, may be made of sheet material or made solid, as desired. A rubber belt 42 connects a pulley on the motor 38 with a pulley attached to the picker or wind roller 40 and thus the picker or wind roller 40 is rotated at a high speed.

I provide still another base 43 which may be made of porcelain segments laid together, the entire base constituting an annulus. I provide still another base comprising a pair of integral porcelain cylindrical pieces 45 and 47 one above the other. These may be dovetailed together if desired. Supported by the base 45 is a wire screen 50 constituting a Faraday cage. This has a door 51 for access to the interior thereof. On top of the upper porcelain cylinder 47 is a cylindrical piece of porcelain 52 of the shape indicated. Supported by the porcelain 52 is a metal bearing 53 which journals a vertical shaft 54. A shoulder 55 on the shaft constitutes a thrust bearing. A disk-like plate 56 is connected to the shaft 54 and supports a skeleton cone supporter 57. A removable cone 58 of the shape now well known for the formation of hat bats is mounted on the support 57. The cone 58, how-

[fol. 730]

over, is preferably smaller than the cones now in use.

Supported by the porcelain 52 is a metal cylinder 60 having a hooded or curved top portion 61 with a front opening 62. A door 63 is provided in the side of the metal cylinder 60.

I provide a motor 70 on the armature shaft of which is a worm 72 meshing with a worm wheel 73. The worm wheel is fastened to a shaft 74 journalled in bearing brackets 75 and 76 which may be attached to the floor. The shaft 74 extends through the base wall 46 where there is a coupling 77 connecting the shaft 74 with a glass rod or shaft 78. The glass rod 78 extends through an opening in the lower porcelain cylinder base member 47 to a coupling 80 which connects the glass shaft 78 to a short shaft 81 on which is mounted a bevel gear 82. The short shaft 81 is journalled in a journal 83 mounted in an opening in the porcelain 47. The bevel gear 82 meshes with a bevel gear 85 which is mounted on the lower end of the shaft 84. Thus when the motor 70 is energized the disk 86 is rotated at a slow rate of speed and thereby the cone 88 is also rotated. The cone 88 preferably has not the usual perforations. The Faraday cage 89 is preferably grounded as diagrammatically indicated in Figure 1.

As will be explained more in detail hereinafter, the cone 88 is charged with electricity and so also is the cylinder 60 and the picker or wind roller 48. Other parts of the machine are insulated. The charge on the picker or wind roller 48 is the same as that on the cylinder 60 and is opposite to the charge on the cone 88. The potential used is or may be around forty thousand volts but I do not desire to be limited to any particular potential. Preferably a potential of five thousand volts and up will be employed and desirably something under one hundred and fifty thousand volts will be employed.

In the manufacture of hats according to the present invention any usual or known fur may be employed. Many hats have been made out of wool and this may also be used in accordance with the present invention. Assuming, for example, that rabbit's fur is used, of the variety well known as B. C. B., this is carroted by the fur cutter in any usual or preferred manner, for example with the use of the carrot patented to Warren C. Mercier consisting of mercury nitrate with an excess of nitric acid and hydrogen peroxide. This carroting operation makes the fur to a limited extent conductive which contributes to the deposit of fur electrostatically according to the present invention. The pelts are then taken to the cutting machine and the fleeces cut therefrom. After that the usual blowing operation may be resorted to to separate the dirt and segregate the fur from the hairs. At that stage the fur may be used pure or filler fur may be introduced in any given amount if desired. Fur carroted as indicated will take a considerable amount of filler fur and the use of the apparatus and method of the present invention also renders it possible to use a large amount of filler fur so that I may use fifty per cent or even more of filler fur if desired according to the present invention.

The fur is fed by the operator into the hopper 35 in any usual or known manner. Mechanical feeders already known may be used if desired; or the operator may merely place the fur upon the traveling belt 36. In any of these cases fur is delivered in regular or irregular amounts to the revolving picker and wind roller 48. Desirably, for the formation of a given hat bat, a weighed amount of fur will be used.

The wind roller or picker 48 operates in the manner already known to throw the fur into the air and forwardly in the form of a cloud or storm of fur. The fur is directed to the opening 62 in the hood 61 of the cylinder 60 of the forming machine. The storm or cloud of fur is charged electrically by the metal picker or wind roller 48 with electricity of a given charge. However the entire cylinder 60 and hood 61 is metallic and is charged with the same charge. The fur is therefore repelled from the walls of the hood 61 and from the walls of the cylinder 60. As it descends in the cylinder 60, which it will do by reason of gravity, it is attracted to the cone 88. Accordingly the entire charge of fur, or substantially the entire charge of fur, is deposited upon the cone 88.

An outstanding difference between the manner of depositing fur upon the cone 88 according to the present invention and according to prior machines which use suction to deposit the fur, is that the fur particles are deposited, according to the present invention, normal to the surface of the cone 88. That is to say, considering any very small area of the surface of the cone 88 as a plane, the fur particles stand perpendicular to the surface; stating this in another way, the fur particles stand radial to the circle of the cone and stand perpendicular to elements of the cone. The top of the cone is not a geometrical cone but is more or less spherical. The fur particles on this portion of the cone 88 stand radial to the sphere.

Furthermore the individual fur particles are evenly spaced upon the cone 88 by reason of the fact that like charges of electricity repel each other and the fur particles as they approached the cone 88 were charged with like charges.

Considering now the electrical diagram of Figure 2, I provide any suitable source of alternating current in power lines 90 and 91. For example 550 volts commercial current may be used, selecting one phase of the three phase current. I provide a switch 92 and a transformer 93 the primary of which is connected to the lines 90 and 91.

The secondary of the transformer 93 is connected to rectifiers 96 and 97. The rectifiers are connected to lines 98 and 99. Lines 98 and 99 are connected by a condenser 100 and a switch 101. Line 99 is connected by a conductor 102 and brush 103 to the coupling 80 which, through the shaft 81 bevel gears 82 and 85 and shaft 84 is electrically connected to the disk 86 and the cone 88. Line 98 is connected by a conductor 105 to the picker or wind roller 48. Line 98 is connected by a conductor 106 to the hood 61.

The lines 98 and 99 may be supported by heavy porcelain insulators 110 and hangers 111 from the ceiling. The cone support 87 is well insulated from the cylinder 60 and the picker or wind roller 48 is well insulated from all parts of the apparatus. The various driving connections are well insulated so that charges of very high voltage can be imparted to the picker or wind roller 48, the hood 61 and cylinder 60, and the cone 88 as described.

A given grade and quantity of fur for the manufacture of hats having been provided, the operator places a weighed amount thereof in the hopper 35 or upon the belt 36. As previously stated, a feeding mechanism may also be employed. The fur is delivered by the belt 36 to

the revolving pick- and wind roller 46. The latter is charged with electricity and imparts a charge to the fur as the fur is blown upwardly in the trajectory entering the hood 61. With the use of mercury nitrate carrot, which has been commonly used in the hatting industry, or with the use of the Mercier carrot heretofore mentioned, a deposit of mercury is left in the fur particles. This makes them to a limited extent conductive and permits the imparting of a charge to them.

As the fur descends in the hood 61 and cylinder 60 it is repelled from the walls thereof and it is attracted to the cone 58. The fur is deposited upon the cone 58 but stands perpendicular thereto.

When the fur has become deposited upon the cone 58 the operator opens the switch 97 and closes the switch 101. The fur will not drop off the cone 58 when the switch 97 is opened because the cone is always wet from the continued application to it of wet cloths and immersion in water when it is on the sinking kettle. The latter will be done carefully because of the charge collected by the condenser 100. When the various parts of the apparatus have thus been discharged, the operator opens the doors 51 and 63 and places a wet cloth upon the cone 58 in the usual manner. He then places a second cone upon the cloth covering the cone 58 and transfers both of them to a sinking kettle in the usual manner. The cones may then be removed from the water and the hat bat taken off the cone 58 and then hardened, started and sized.

An outstanding characteristic of hat bats produced according to the present invention is that the fur is much more densely packed. I have observed that in the sizing of hats, statistically speaking, the fur fibres move outwardly. Since in the normal operation of making a hat the hat bat is a very tenuous body of large dimensions and the final hat body is a densely felted article quite thick but much smaller in area than the hat bat, it must be concluded that the fur, statistically speaking, moves outwardly; a mere interchange of fur fibres in the plane of the hat bat or hat body will not cause shrinking and sizing. By starting with a hat bat the fibres of which have been laid normal to the surface of the cone a much denser packing of the fur is achieved. It will be understood that the winding of the usual cloth over the deposited fur on the cone 58 will temporarily alter the position of the fibres normal to the cone but they are simply kept over and can more readily assume their given position. Furthermore the interfelting will leave them in all and sundry positions. Nevertheless the majority of the fibers are already started on the sizing or felting operation and therefore there is less sizing of the hat bat to be performed in the subsequent sizing operation and the hat bat is denser than previously known hat bats. This enables me to use a smaller cone 58 than has heretofore been used for a given size of hat. It also tends to standardize the amount of sizing or shrinking.

Referring now to Figure 3, a specially shaped "cone" 120 is therein shown more in the shape of a finished hat than the usual cone now provided. By reason of making a dense deposit of fur partially oriented in the formation of the bat and by reason of the lesser amount of shrinking in manufacturing hats according to my invention I can use a cone which is nearer to the final shape of the hat than has heretofore been used. Thereby the manufacture of hats is simplified.

The provision of the Faraday cage 58 is to provide an effective shield against a discharge of electricity from the cylinder 60 on to the operator and otherwise as a protection. In the foregoing description I have used the term "bat" accurately I believe to refer to the body formed by deposit of fur upon a cone and prior to the time when the shrinking is "started"; that is prior to the "starting operation." However the term "hat bat" and the term "hat body" should be interpreted broadly in the claims since the one proceeds out of the other.

It will thus be seen that there has been provided by this invention an article, a method and an apparatus in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth, or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. Method for forming hat bats by projecting fur in a storm from a wind roller to a forming cone which consists in establishing an electric field of high intensity between the wind roller and the forming cone.

2. Method according to claim 1 in which a given charge is impressed on the wind roller and an opposite charge upon the forming cone.

3. Method according to claim 1 in which a container is provided for the cone, a given charge is imparted to the container and the wind roller and an opposite charge is imparted to the forming cone.

4. Apparatus for forming hat bats comprising a forming cone, means to rotate said forming cone, means for delivering particles of fur above said forming cone, and means for creating an electrical field of high intensity having a total voltage difference of at least five thousand volts between said means for delivering fur and said forming cone whereby the fur is electrically directed to the forming cone and deposited thereon.

5. Apparatus for forming hat bats comprising a forming cone, means rotatably supporting said forming cone, insulating means for said forming cone, means to rotate said forming cone, a cylinder surrounding said forming cone, a picker roll positioned to direct fur into said cylinder, and means for creating an electrical field of at least five thousand volts potential difference between said picker and said forming cone.

6. Apparatus as claimed in claim 5 including also a Faraday cage around said cylinder and said forming cone for the protection of the operator.

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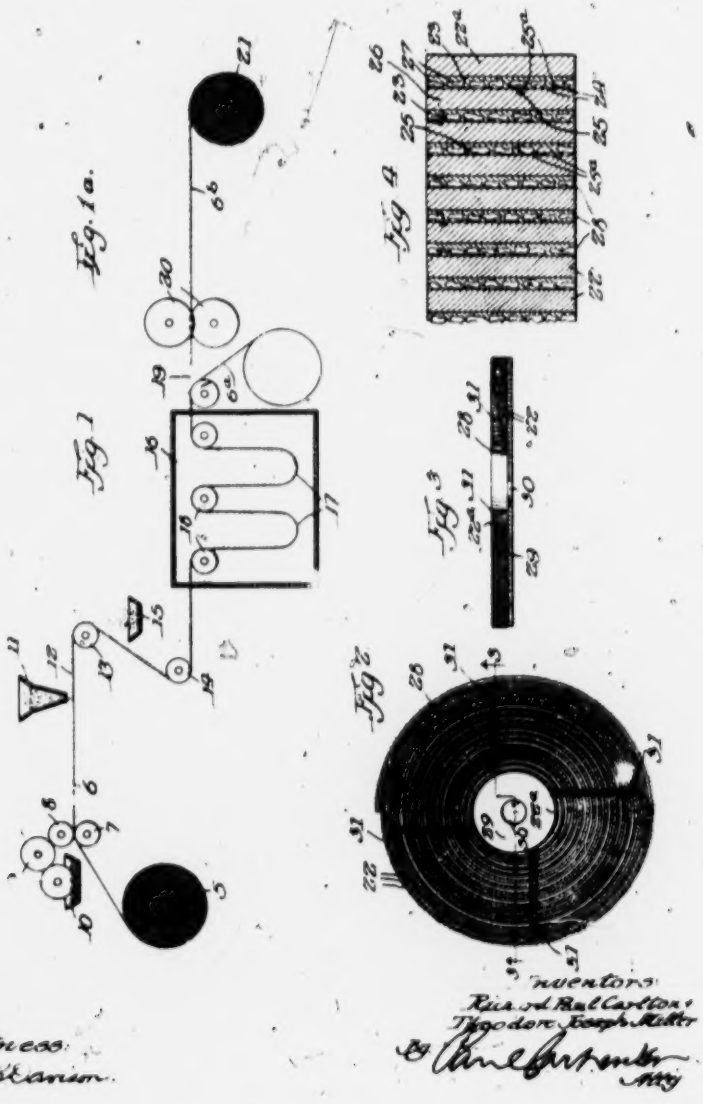
[fol. 732]

July 8, 1941. R. P. CARLTON ET AL 2,248,064

COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 1



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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 2

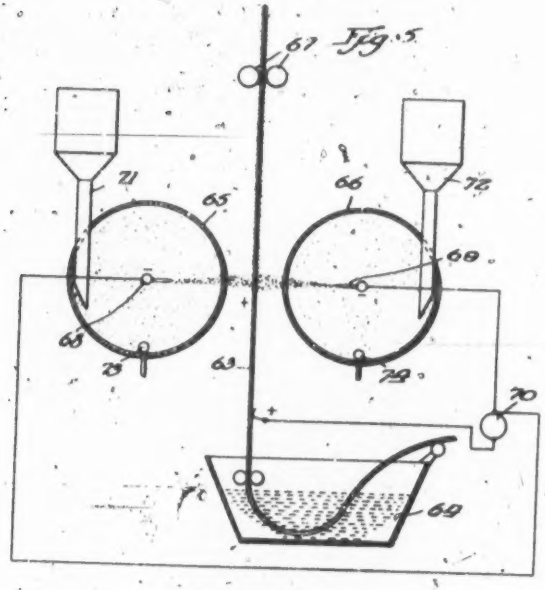

Fig. 5

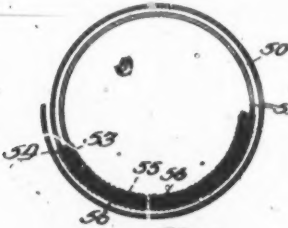

Fig. 6

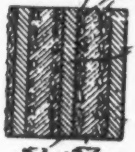

Fig. 7

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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 3

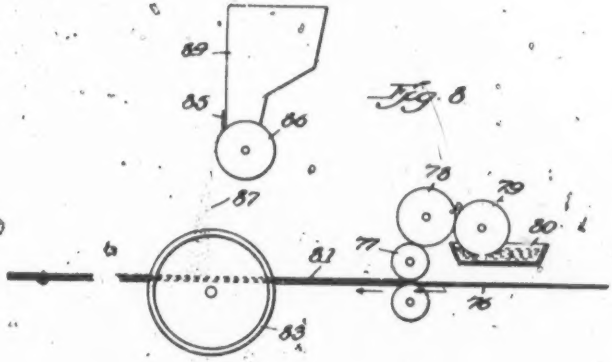

Fig. 8

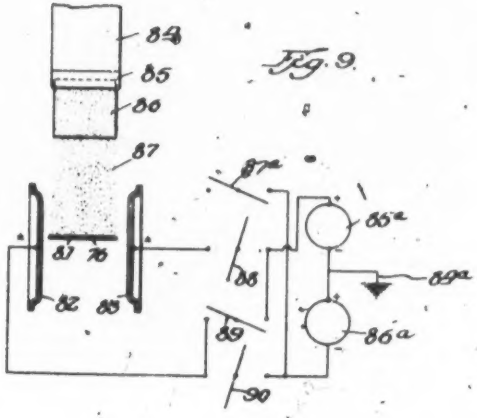

Fig. 9

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[fol. 735]

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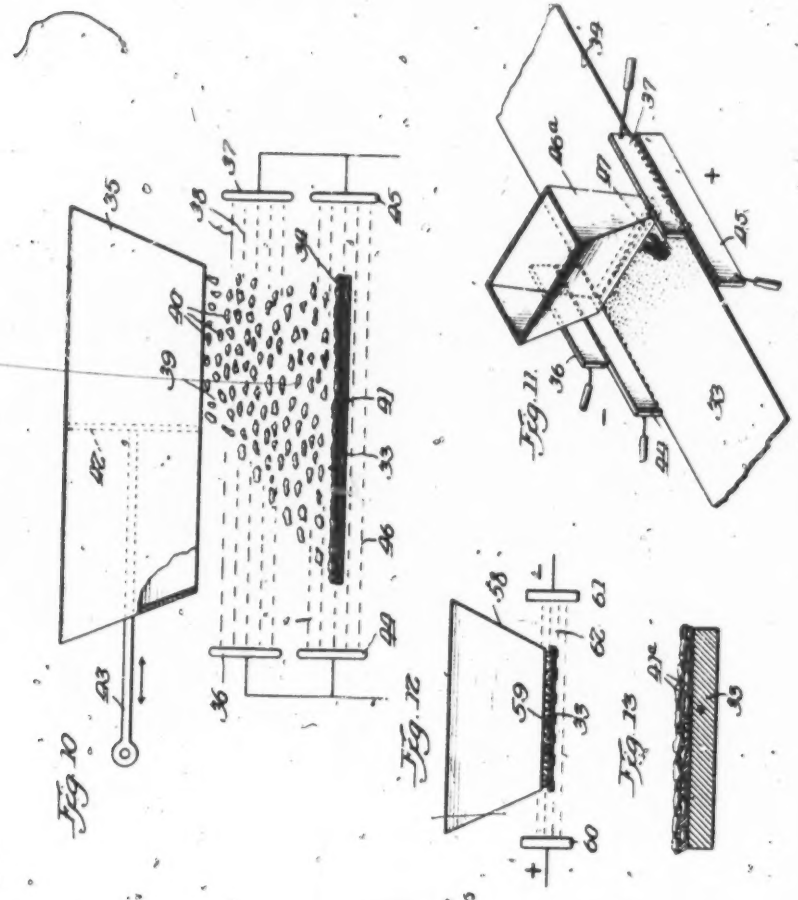
COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 4



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[fol. 736]

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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 5

Fig. 14

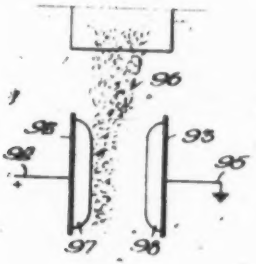


Fig. 15

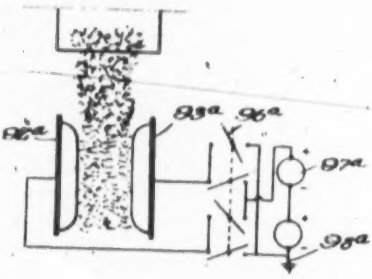
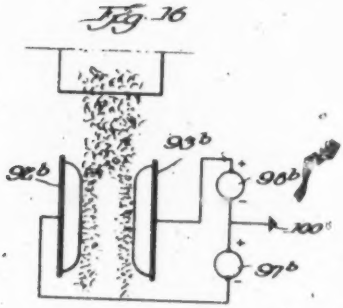


Fig. 16



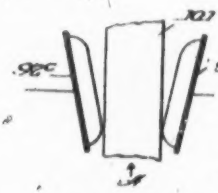


Fig. 17

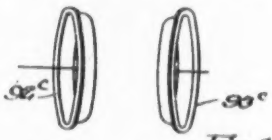


Fig. 17a

Fig. 18.

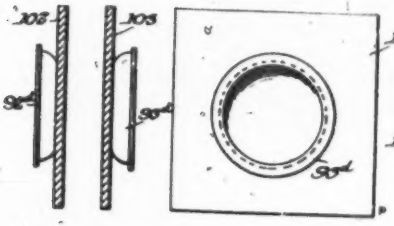
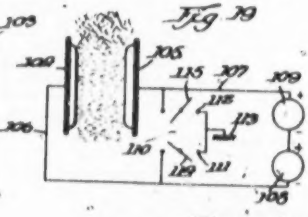


Fig. 18a

Fig. 19



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[fol. 737]

Patented July 8, 1941

2,248,064

UNITED STATES PATENT OFFICE

2,248,064

COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Richard Paul Carlton and Theodore Joseph Miller, St. Paul, Minn., assignors to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware.

Application June 1, 1932, Serial No. 612,526
Renewed March 21, 1936

10 Claims. (Cl. 51—192)

This invention relates broadly to coating and coating materials especially in sheet form, such as in the manufacture of abrasives, and the present invention among other things finds utility in one of its phases in the manufacture of abrasive wheels or discs, and while the invention in one of its forms is illustrated as adapted for coating and forming an abrasive disc, it will be understood that certain other phases of the invention are of quite general application and may be adapted for other purposes, such, for example, as a method of coating roofing material with pulverulent mineral.

This invention, as will hereinafter appear, finds especial utility in the production of grinding discs wherein the abrading surface is on a side thereof rather than on the periphery; and the invention also finds utility in coating roofing material so that particles of mineral deposited thereon are caused to lie flat, that is to say, with their major dimensions substantially parallel with the surface of the backing.

The customary procedure generally resorted to in the manufacture of abrasive wheels, discs and the like generally includes the mixing of an abrasive grit, such as aluminum oxide, silicon carbide or emery, with a suitable bonding material and then placing the mixture in a mold. The final setting up of the bonding material is then effected by curing at a sufficient temperature to cause the bond to flow and take a firm grip of the abrasive grit. Several different forms of the adhesive or bonding material are used, the more common being that known as a vitrified or ceramic bond. In making such a wheel it is necessary to fire the wheel, that is to say, subject the mixture of bonding material and grit to a sufficiently high temperature to cause the bonding material to flow and thus, in effect, form a porcelain bond between the various particles of grit. Obviously, such a wheel or disc is inflexible, broadly, and will not stand shock or sudden thrusts.

It has been proposed to employ as substitute bonds for the vitrified or ceramic bond, materials such as rubber, shellac, sodium silicate, natural and synthetic resins and the like.

In producing an abrasive disc or wheel, aside from the problems of choice of bond, there is also the necessity of controlling the ratio of bonding material to abrasive material, and it is also highly desirable that, in certain forms of the abrasive wheel or disc structure, more or less porosity or voids in the wheel acting as clearances for the material being abraded be provided so that fast and continuous cutting, together with reduction in temperature of the wheel when engaging the work, should be attained. In obtaining these desiderata it is found that the porosity of the wheel in the case of a molded structure tends to weaken the disc or wheel and, due to the porosity, the structure does not have sufficient bond to firmly anchor the grit therein.

The principal objects and advantages of the present invention reside in the provision of an improved method of manufacturing an abrasive wheel, disc or the like having characteristics in its structure which increase the cutting ability, strength and durability of the device; the provision of an improved method of manufacturing an abrasive article such as a wheel or disc for abrading purposes, in which the cost of manufacture is considerably reduced, with the attendant accomplishment of the desired control of ratio or bond, that is to say, adhesive, to the mineral or grit, and to provide such an improved method in which the same may be carried out as a substantially continuous process, thus simplifying the manufacture and reducing the ultimate cost; the provision of an improved method of manufacturing abrasive wheels and discs in which a fabric such as paper, cloth or the like may be employed as a carrier for the bond and grit and in which the ultimate size of the abrading wheel or disc may be determined easily and by a substantially continuous method; the provision of an improved form of abrading wheel or disc wherein a controlled porosity of the structure is obtained and wherein the ratio of adhesive material to grit is substantially uniform throughout the entire wheel or disc; the provision of an improved abrasive article such as a wheel or disc wherein the grit particles are oriented so that their most effective cutting edges are presented at the abrading surface and thus are brought into contact with the work more efficiently; the provision of an improved method of manufacturing abrasive discs, wheels and the like in which the production of the abrasive article may be carried out on existing sandpaper type of equipment, with the subsequent convenience of shortening the required time for producing various sizes of abrasive wheels and discs.

A further advantage of this invention resides in that, as distinguished from the molding process of making abrasive discs and wheels, which requires that the abrasive grit and bonding material be mixed in the proper ratio, then molded, then heated, and therefore requiring each separate size of wheel or batch to be handled completely individually from the beginning to the end of the

[fol. 738]

entire fabrication process, the present invention permits of the carrying out of a substantially continuous process similar to the manufacture of sandpaper and that continuous lengths of the material may be stored in drums or rolls from which the desired width of strip may be cut which is to determine the ultimate thickness of the wheel, it being assured at all times that the ratio of abrasive material to bonding material will remain substantially uniform throughout the particular wheel or disc structure which it is desired to form.

The present invention also permits of the manufacture of the basic abrasive material on standard sandpaper equipment and that this material may, after having been prepared, be preserved in stabilized form for use in manufacturing wheels as desired, the process and the article thus permitting of the production of one or more wheels of a desired size and texture, that is to say, grit size or number, at less cost and more conveniently than is possible with the previous processes known to us.

It has also been suggested in the prior art that abrasive discs and wheels be made up of a series of superposed discs of ordinary sandpaper, emery paper or cloth or the like glued together and subjected to pressure and heat, but in such prior process and articles made therefrom known to me considerable waste occurs in that the discs must be cut from a standard made piece of sandpaper, and the portion thus made and not used must be thrown away. The present invention distinguishes from such process in that there is substantially no waste of abrasive material which is attendant upon any disting out process, hitherto suggested.

The present invention also has as one of its objects the provision of an improved method of producing a flexible abrasive article and the resultant article so that, as desired, the manufacturer may produce an abrasive article of the desider degree of flexibility, and, at the same time, have a substantially homogeneous structure with a substantially continuous abrading surface.

The present invention also contemplates the employment therein and for the production of the abrasive article of a new process of orienting the abrasive grains so that their sharper points will be presented at the abrading surface. In ordinary sandpaper the abrasive grains are deposited on the adhesive coated sheet by gravity and as a result lie in haphazard fashion in the adhesive.

In the present invention it is desirable that the abrasive grains be oriented so as to present the longitudinal axes of the individual particles in a position substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof so that when the abrasive article is formed from a sheet of abrasive material made according to this invention, to form an abrasive disc, the sharper points of the grains will be presented at the margins at each of the convolutions of the disc.

This orientation of the grains may be conveniently accomplished by the action of an electrical field, and it is therefore one of the further objects of this invention to provide an improved method of and apparatus for subjecting the abrasive grains to the action of an electrical field for the purpose of attaining the desired orientation of such particles; the invention further has as one of its objects the improved method of and apparatus for subjecting the abrasive grains during the flight by gravity to the sheet to the effect of an electrical field, preferably of the electrostatic type, for aligning the particles with the lines of force of the field, which for convenience lie substantially parallel with the surface of the abrasive sheet, thus orienting the grains in the proper desired manner as they are deposited thereon.

This invention also contemplates the improved method of incorporating the grit particles in an adhesive in plastic form, and while the same is deposited together with the grit on a flexible backing subjecting the incorporated grit and adhesive to the action of an electrical field for aligning the particles and orienting the same in the desired manner.

The method involved in the present invention may be carried out in a number of alternative steps, depending upon the form and characteristics as to flexibility and denseness which it is desired to impart to the finished article.

A preferred method of producing the abrasive article of this invention includes the selection of a fabric, preferably paper, of a desired and suitable weight, coating this paper with a bonding material and a suitable grit. For our purposes we prefer to employ a waterproof bond, and, for example, this may be any of the bonds described and claimed in the patents to Okie 1,865,027, 1,865,028, 1,638,991, Carlton 1,775,631, 1,736,964.

This paper thus coated with a waterproof bond and a suitable grit may be of the same characteristics as the waterproof sandpaper now known to the trade as "Wetordry."

The coated fabric, preferably paper, having the grit contained in the adhesive layer may be provided with a light or heavy sizing coat, depending on the use to which the material is to be applied, though in most instances a sizing coat may be omitted.

After the bond and adhesive or grit have been applied, the material is then festooned for a sufficient period of time to dry or partially solidify the adhesive. It is preferable that the adhesive be not set to its final condition at this time but to aid in handling the adhesive should be dried to a degree which will prevent accidental displacement of the grit.

The abrasive sheet thus formed may be rolled into what are known as Jumbo rolls and may be stored until required for slitting into suitable widths. When it is desired to complete a grinding disc with this material the same may be slit to any desired width which is to be the depth of the disc or wheel and then wound into rolls of the required diameter. Owing to the fact that the adhesive material is not entirely set when the sheet is wound into a roll, the disc or wheel thus formed may be placed in an oven for further drying and for completely setting up the bond.

By regulating the tension of the strip of abrasive material as it is wound into disc-like form the compactness and resultant flexibility of the final product may be desirably controlled.

It will be understood, of course, that the resultant flexibility of the article is more or less dependent upon the type of adhesive employed, and that by controlling the flexibility of the adhesive and the tension upon winding the ultimate flexibility of the article may be regulated. As to the waterproof qualities of the article, excellent results may be obtained by employing any of the binders disclosed in the patents mentioned herein.

In the actual finished disc material thus produced particularly where the strip of adhesive

material is relatively loosely wound to form a disc, the convolutions thereof will afford clearance spaces, though they may at numerous points be adhering together by virtue of the adjacent layers of the adhesive. In the actual finished article we thus are able to produce an abrading surface which has sufficient flexibility as to binder and composite to facilitate surface sanding, as it is called, and also to facilitate clearing of the wheel when it is in use.

We have found that in some cases of flexible discs or wheels it may be desirable to cement the layers or convolutions of the disc together, but this is not the preferred practice for the normal surface sanding job, and we have found that for such purposes merely winding the strip of material upon itself and then attaching it to a suitable backing, preferably flexible in nature, will produce a grinding wheel or disc giving a desirable flexibility and an efficient cutting surface.

In instances where it is desired to make a solid wheel, that is, a relatively inflexible wheel or disc, it may be desirable to cement the laminations, layers or convolutions, as they may be termed, and this may be accomplished by interposing a sizing coat as the strip is wound into the disc form. It also may be desirable in some instances to apply the sizing material in a relatively heavy coating and to subject the article to heat for causing the coating to flow, and thus relatively intimately connect adjacent layers of the abrasive material.

This operation may also be accomplished when the disc is wound by immersing the same in a bath of adhesive size to permit the adhesive material to flow by capillary action between the laminations or convolutions of the disc.

One of the important factors which effect flexibility when the disc is not of the solid type is the degree of tightness of winding, and thus by relatively loosely winding the strip of adhesive material it is possible ultimately to obtain a very flexible abrasive disc.

It is important in the production of a grinding or polishing disc or wheel of the character herein disclosed that the ratio of mineral grit to adhesive be controlled to produce the most desirable coating results and also that the uniformity of this ratio throughout the disc be maintained. By the abrasive article of this invention and the method of manufacturing the same, we are enabled to attain a high degree of efficiency in cutting operations of the disc and to give to the abrasive article a substantially uniform effective abrasive surface throughout, so that as the same becomes worn in service it yet renders the same efficient cutting and/or abrading or polishing functions.

It will be understood, of course that dependent upon the desired characteristics of the finished product, we may employ fine, medium or coarse grits and that, correspondingly, the thickness of paper and other fabric employed and the ratio of adhesive to grit or abrasive particles must be controlled in each instance to the desired degree. In certain instances we applied the adhesive and abrasive coatings to both sides of the backing.

In selecting an adhesive material, we have obtained excellent results with adhesives formed as composite materials from Bakelite, that is, phenol and formaldehyde and other synthetic resin binders, rubber, shellac and the like, it being understood that these materials may be made into a liquid adhesive and can be further molded or softened by subsequent flowing under heat in such manner that a thorough setting or curing of the adhesive is accomplished without detracting from the flexibility thereof.

One example of an adhesive which is suitable for our purpose is that substantially according to the following formula:

	Parts
Bakelite resin	4
Thinner (denatured alcohol)	1

This composition is agitated very thoroughly until a creamy fluid possessing some tackiness is produced. This adhesive is then applied to the sheet which then receives the abrasive material.

In the case of a Bakelite resinous material, the adhesive is dried after having received the mineral either on the racks or festoons or at some other point in the production of the abrasive strip, and we prefer to employ temperatures ranging from normal atmospheric room temperature to approximately 140 degrees Fahrenheit, depending on the length of time of drying. In this drying operation the temperature is maintained at such a point that the thinner or solvent only will be driven off and thus no appreciable hardening or solidifying reaction takes place in the resin at this time. When the strips are coated with this material together with a binder, heat treated as set out above and then wound into discs or wheels, they may be further subjected to heat which causes a flowing of the resinous binder and thus sufficiently unites the several convolutions or laminations of the wheel. Of course, if it is desired to make a substantially rigid wheel in this manner, the same may be tightly wound and also subjected to pressure as well as heat subsequently.

When employing a synthetic resinous material such as a Bakelite resin, the same is thinned with a suitable thinner and coated on the sheet in the same manner as that employed in conventionally forming sandpaper. The grit is then applied as quickly after the binder application as may be practicable. The thinners are evaporated at normal temperatures, and the bond thereupon solidifies to the consistency of a varnish partially dried but tack free.

The abrasive article in this condition may then be stored in large rolls and cut or slit into ribbon disc portions as required.

In order to insure flexibility of the abrasive article during handling, it is preferred that the rolls be stored in a humid atmosphere, so that the article will be possessed of flexibility during the heating operation.

After the abrasive material is cut and formed into ribbon discs, the bond may be toughened by further heat treatment at, say, 180 to 185 degrees Fahrenheit for approximately fifteen minutes, which produces a flexible consistency and is suitable for some purposes, or, we may employ temperatures ranging from 250 to 300 degrees Fahrenheit for a period of time of from fifteen minutes to one hour to produce a relatively hard bond in which there is substantially no flexibility in the binder coat itself. Where a flexible binding coat is desired, a proper regulation of the temperatures and employment of a suitable modifier in the Bakelite resin will give satisfactory results.

It will be understood that the preference in storing the abrasive in large rolls, jumbo rolls as they are called, is that sometimes it is difficult to synchronize the heating operation with the

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drying festoons, and for some purposes it is preferred that the abrasive sheet as it is formed be pieced in jumbo rolls so that it may be slit to the desired widths as required.

In connection with the foregoing formula we have secured a flexible abrasive strip to be wound into a disc or wheel shape by employing a Bakelite material which does not produce a complete reaction to rigidity or by keeping the temperature below 212° F. and reducing the time of heat treatment.

For the purposes of this invention we prefer to employ a flexible binding material on the flexible backing, but it is to be understood that a satisfactory flexible wheel or disc may be produced employing a relatively less flexible binder by keeping the layers or laminations of the wheel separated.

We have made satisfactory abrasive wheels or discs by employing an adhesive of the varnish type such as is disclosed in the patents to Okie hereinabove referred to, and we have also employed as a binder the material disclosed in the application of Carlton and Oakes, S. N. 660,319.

Where rubber, shellac or synthetic resins other than Bakelite are employed, we also prefer to heat treat the same in the final setting or, if necessary, after first applying the binder to the strip which is to be later wound into the disc form. With rubber, sulphur is added in desired amount to the adhesive material so that the vulcanization of the binder takes place in the heating step.

Under some circumstances, in order to prevent starving of the bond between the grit and the sheet, it is desirable to apply sizing coat to the back of the sheet, and this may be done during the winding of the sheet or after the original process of making the sheet simultaneously with the application of the adhesive and grit.

The outstanding advantages of the present invention, particularly where the same is wound into a roll to form a disc or wheel, reside in that we are enabled to produce a laminated abrasive structure in which the abrading surface presents a more definite and more uniform porosity due to the laminations and due to the spot contacting of the adhesive on one layer with the adjacent layer, and thus producing a greater proportion of voids than is possible or obtainable where abrasive grit and a bond are molded even where equal ratios of bond to grit are employed. Our invention also produces a laminated abrasive structure having an increased strength due to the incorporation therein of the coated backing of fabric such as paper or cloth, which adds to the strength of the entire wheel making the same less brittle and more flexible and permitting of thinner wheels to be prepared than by any other prior method known to us.

Another distinct advantage of our invention resides in the fact that the mineral grits, owing to their elongated nature, may be oriented on the abrading device so that their sharp points are presented at the abrading surface. For some purposes it is desirable to deposit the abrasive grit by an electrical field or other electrical action, such as by an electrostatic field, in such a manner that the grits will become oriented with their major axes parallel to the surface of the sheet and perpendicular to the abrading surface, particularly where the grits are placed so that their major axes are perpendicular to the margins of the strip from which the wheel is wound. We shall describe such a process of deposition of the grits more fully hereinafter.

It will be understood, of course, that after the abrasive strip has been wound to the desired diameter and with the desired degree of tightness, a suitable disc backing may be affixed by a waterproof binder if desired on one surface of the resultant abrasive disc so that the disc may be mounted on a suitable shaft for imparting rotation thereto.

The several methods which may be employed in the manufacture of the abrasive article itself are illustrated in the accompanying drawings, in which—

Figure 1 is a schematic view of an apparatus which may be employed for producing the abrasive article of this invention.

Figure 1a is a schematic view of a slitting and winding apparatus which may be used with the apparatus shown in Figure 1.

Figure 2 is a plan view of an abrasive disc made according to this invention.

Figure 3 is a transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 4 is an enlarged transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 5 is a schematic view of apparatus for coating one or both sides of the abrasive article.

Figures 6 and 7 are fragmentary sectional views of an alternative form of an abrasive article made according to this invention.

Figure 8 is a schematic view of an alternative form of apparatus for securing orientation of the abrasive particles.

Figure 9 is a view showing the apparatus of Figure 8 from another aspect.

Figure 10 is an elevational schematic view illustrating alternative apparatus for carrying out the step of orientation of the abrasive particles.

Figure 11 is a perspective view of an alternative form of apparatus of this invention.

Figure 12 is an elevational view of a still further modified form of the invention.

Figure 13 is an enlarged sectional view of a sheet illustrating the alignment of the abrasive grains thereon.

Figures 14, 15, 16, 17, 17a, 18, 18a, and 19 are all diagrammatic views of alternative forms of the invention shown in Figures 8 and 9.

Referring now more particularly to the drawings, and first to Figure 1, there is shown a roll of fabric such as paper or cloth 6, from which the web 6 is unwound over an idler roller 7, to receive from a coating roll 9 a layer of the adhesive material delivered by the series of feed rolls 9 from a tank 10. The web 6 is fed beneath a hopper 11 from which is supplied a quantity of comminuted abrasive material 12 by gravity, which may be suitably regulated in any desired manner to determine the thickness of the grid layer. The sheet or web 6 is then trained over a roll 13 and reflexively bent upon itself by a roll 14, some of the grit in excess of that desired being removed by falling by gravity into a container 15. The web 6 with the layer of grit secured thereto by an adhesive, waterproof if desired, is then fed into a drying room or oven 16, and arranged in festoons 17 by the provision of rolls 18 in said drying room.

The temperature of the drying room is maintained at a degree which will only partially set the adhesive sufficiently to permit handling of

the abrasive coated strip or sheet indicated at 6a as it leaves the drying room. At this point Figure 1 shows the sheet as broken, indicated at 10, inasmuch as it may be desired to store the resultant product of this point before continuing the same to the slitting apparatus. However, if it is desired to have a continuous working process, then the sheet or web is supplied to slitting apparatus represented by the cutting knives 12. These knives may be arranged at any convenient distance apart, depending on the width or thickness of the strip to be cut and ultimately wound into the abrasive discs.

From the slitting apparatus the several resultant strips of abrasive sheet material may be fed to a mandrel 21, on which they may be wound into the final abrasive disc elements producing this article such as shown in Figures 2, 3 and 4.

It will be understood that while the strip shown at 6b in Figure 1 is wound with the abrasive coated side outwardly, thus leaving an outer abrasive coated surface exposed at the last convolution, the disc may be as readily wound in the opposite direction so, that the abrasive coated surface of cloth lamination will be presented inwardly. Inasmuch as these discs are intended to grind on one of their side faces, and as a substantially continuous abrasive coated surface is thus afforded, the discs may be wound either way desired.

It is also to be understood that by pinching the strip 6b under more or less tension as desired, a tighter or looser wound disc may be obtained.

When the abrasive material is deposited by gravity as shown in Figure 1, it will be understood that the abrasive grains will be largely lying haphazard on the abrasive surface, though a large number of them will be oriented so that when the strip 6b is wound into a roll to form the disc the grains will be knocked down in such a manner that their sharper points will, as the disc is employed in grinding or polishing the surface, be brought against the surface of the work. However, to insure that the majority of the grits will be so oriented, we have provided methods and apparatus for so orienting the grains which will be described more fully hereinafter.

Figures 2, 3 and 4 illustrate a disc made according to this invention, wherein the disc is composed of a plurality of convolutions 20 of abrasive coated material affording a laminated abrasive structure. The laminations are held together by the adhesive material establishing contact on one convolution with the back surface of the adjacent convolution, so that a structure somewhat similar to Figure 4 will be obtained, the innermost convolution 20a having its coating 21 of adhesive material contacting at a plurality of points, indicated at 24—24 with the back surface 22 of the immediately adjacent convolution 20. Thus the abrasive grains indicated at 27 in the layer of adhesive 23 are substantially embedded therein with their major axes and thus their sharper cutting points presented toward the margins of the laminations. In this way a substantially continuous abrading surface indicated at 28 on the surface of the disc is thus provided. It will be understood that care must be exercised that the proper weight of paper with regard to abrasive and adhesive be selected.

The disc-like structure thus provided may be secured to a flexible backing 29 of paper or cloth or other suitable material having an axial opening 30 by which the same may be attached to the rotating shaft of a grinding machine.

It will be understood that the backing 29 should be connected to the disc by a flexible waterproof adhesive similar to that employed in the disc itself, or, if desired for some purposes, the backing 29 may be of a rigid material and the disc likewise connected thereto.

In Figure 4, it will be understood, of course, that the thicknesses of the convolutions and layers of grit and adhesive have been greatly exaggerated in size, although it is conceivable that one might produce an abrasive article having convolutions whose thicknesses are as great as those shown in Figure 4. However, in the ordinary form of the invention for employment in standard surface grinding the disc is made up of a sheet not substantially greater in thickness than a sheet of ordinary sandpaper, thus leading to the final product a desired degree of flexibility.

It will be observed that in some instances it may be desirable to provide grooves in the abrasive surface 28, these grooves being shown at 31 in Figures 2 and 3. It will also be noted that the grooves 31 are preferably of greater depth at their inner ends toward the axis of the disc than at their outer ends adjacent to the periphery of the disc. These grooves may be formed in the disc after the fabrication of the same inasmuch as forming the grooves in the strip prior to finally winding would require considerable care in aligning the notches in each convolution from which these grooves are formed.

The disc thus formed contains a number of voids which are afforded by virtue of the grit particles themselves holding the laminations apart acsdsly the vacant places indicated at 32 where the glue or other adhesive does not completely fill the spaces between the convolutions. Thus the abrasive article quickly cleans itself as it works and clogging or loading of the article is practically impossible.

We have found that a satisfactory grinding and polishing wheel may be constructed by methods disclosed herein, and in one form of the invention, which is illustrated in Figures 6 and 7, we apply a coating of adhesive material containing an abrasive to both sides of the strip forming the flexible abrasive article. This coating operation may be accomplished by the apparatus shown in Figure 5.

After making a double coated strip, it is then wound loosely into a configuration substantially like that shown in Figures 6 and 7. The thus wound material is then thoroughly cured and dried. After curing, the disc-like structure thus afforded is connected to the cloth backing in such a manner as to preserve the open or spaced convoluted structure as shown. The polishing compound, which may be according to the formula appearing below, is then forced into the spaces between the layers and when completely filled with polish the disc is then allowed to sit for sufficient time to solidify the polish here. This drying time, we find to give best results by subjecting the article to a drying temperature for approximately forty-eight hours.

A satisfactory formula which we have employed for the purpose of compounding the polishing material may be as follows:

	Grams
Nitro base thinned to 30% solids	200
Dibutyl phthalate	45
400 dc	68.5
Tripoli	102.5
Borax	11.5
Stralite	45

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From the foregoing it will be observed that we produce a convoluted structure indicated generally at 93, composed of the laminations of the convolutions 94 of suitable fabric coated on both sides as indicated at 95 and 96 with adhesive 95 containing the comminuted abrasive material 90.

It will be noted that sufficient space is afforded between the layers 94 particularly as shown in Figure 7 to permit of the introduction of a comminuted polishing material indicated at 97. Thus the finished article possesses both grinding and polishing properties.

It will be understood that it is highly desirable that the comminuted abrasive material be disposed on the strip or sheet in such manner that the individual grits will have their major axes preferably lying parallel with the surface of the sheet, and, where the sheet is to be wound later to form a disc, which marginally exposes an edge of the sheet for forming the abrasive surface, that the grits be perpendicular or substantially perpendicular to the longitudinal margins of the sheet.

While orientation of the grits with their major axes parallel with the surface of the sheet and substantially perpendicular to the edges thereof, may be more or less accomplished in simple gravity deposition of the grits on the adhesive coated sheet, a positive orientation of the individual grains may be accomplished by electrical action, that is to say, the grits may be deposited on the sheet in the presence of an electrical field, for example electrostatic, or if the grit particles are of a magnetically responsive nature then in the presence of an electro-magnetic field. Grits deposited in the presence of such an electrical field will be caused to align themselves with the lines of force of the electro-magnetic or electrostatic field as the case may be.

For most abrasive articles an electrostatic field will perform the function inasmuch as most of the grit particles commonly employed in the abrasive arts are of a non-magnetic character and are non-conductors and practically all will respond to the force of an electrostatic field.

Referring specifically to Figure 5, we provide a suitable backing for carrier strip 60 which receives coats of adhesive material on both sides thereof from a suitable tank 64, the strip being conducted upwardly between two chambers 66 and 66 and then conducted through edge guide rollers 67.

In the chambers 65 and 66 there are provided electrodes 68 and 69 of preferably negative polarity, the sheet being itself of a conductive nature and connected to the positive side of a source of electric motive force indicated at 70.

The apparatus receives grit from hoppers 71 and 72 which is agitated in the form of clouds within the chambers 65 and 66 by air blasts introduced at the nozzles 73 and 74.

The apparatus shown in Figure 5 is similar to that shown in the patent to Simyar 1,788,600, and serves to illustrate one apparatus for carrying out the double coating simultaneously. This form of the apparatus does not, however, produce orientation of the grit particles with their major axes parallel to the plane of the sheet, and reference will be made hereinafter to forms of the invention including apparatus for this purpose.

It will be understood that the sheet may be coated on both sides by running it twice through either a gravity coating apparatus or any of the apparatus shown in the other figures of the drawings.

As herein pointed out, it is desirable to orient the grit particles so that they will lie with their major axes substantially parallel to the surface to be coated, and they will, thus present their sharp points at the edges of the strip as the same becomes worn in use; as abrading disc.

This orientation of the particles uniformly on the sheet is also of utility in the manufacture of mineral coated shingles wherein it is desirable that the particles of mineral, granules or the like, be deposited so that a minimum number of the mineral granules is required to cover a given area of the asphaltum sheet or other material from which the carrier or backing of the shingle is made.

We have illustrated herein a number of ways in which this may be accomplished which are all included in the disclosures of Figures 5 to 12, both inclusive, and Figures 14 to 18, both inclusive.

With reference first to Figures 8 and 9, we have employed a backing 76, of suitable material which receives a coating on the upper surface of the horizontal flight thereof shown in Figure 8, this coating being applied from a set of adhesive distributing or applying rollers 77, 78 and 78, the latter taking up adhesive from a tank 80. This adhesive layer is indicated at 81 and the backing is then propelled to the left as viewed in Figure 8 between electrodes forming an electrostatic field.

These electrodes, we have found, may conveniently comprise a pair of circular disc-like plates 82 and 83, between which the horizontal flight of paper 76 passes at desired rate of speed. Other forms of the plate electrodes may be employed, but we have found that this type produces a uniform field and highly satisfactory performance.

Above the flight 76, and at a distance sufficiently remote from the electrodes so as to be substantially unaffected thereby, we provide a hopper 84, which may contain abrasive grains of the desired size. We find that for our apparatus an abrasive grain or pulvule of a silvery character that is somewhat elongated, will give highly desirable results as to orientation, though it will be understood that it is not necessary that this type of pulverulent material be employed in order to attain the results of this invention. Practically all of the grits employed in the abrasive industry to-day are characterized by having a major and a minor axis so that they become responsive to the action of an electrical field when introduced into the presence of the same.

These grits are deposited by gravity from a hopper 84 having a suitable controlling gate 85 over a distributing roller 86 so that they fall in a substantially continuous stream 87 toward the adhesive surface 81, passing between the electrodes 82 and 83 in their path to the adhesive surface.

We have discovered that a static electrical field solely, that is to say, without outside influence, mechanical or otherwise, acting upon the grit particles, tends to deflect them toward one of the plates, and in order to correct this and produce a more uniform distribution and yet obtain orientation, we employ a pole changer, diagrammatically illustrated in Figure 9, through which the two electrodes 82 are connected to the source of electrical difference of potential.

A source of electromotive force, preferably of relatively high voltage, is provided. The voltage employed in one arrangement of the electrodes was about 165 kilovolts and in employing this voltage the plates or electrodes were spaced about 5.5 inches apart in air. This arrangement served to maintain a constant electrical potential gradient of approximately 19 kilovolts per inch between the electrodes.

In correcting for uneven distribution, one side of the source of difference of potential is grounded as indicated at 36c in Figure 9, and the source comprised of two units 36a and 36b is so connected through pole changing switches 37a, 38, 39 and 40 that the relative polarity of the two plates 32 and 33 forming the electrostatic field was changed at a desired frequency.

We have found that, for our purposes, with the plates spaced between 5 and 6 inches apart in air, the best results are obtained by the use of electrical potential gradients of the range of from 17 to 20 k. v. per inch. We also find that where reversal of polarity is resorted to, as in the disclosure in Figure 9, the optimum of frequency of polarity change or reversal should be in the vicinity of two cycles per second. However, we have found that ranges of from one cycle per second to four cycles per second produce satisfactory results and that little change was noted in thereby producing satisfactory distribution and orientation of grit particles on the sheet.

It will be understood that the foregoing disclosure of values as to voltages, rates of polarity change, and size of and distance between the plates is all subject to variation to suit the particular conditions and results to be attained thereby.

We have also found that with different types of abrasive grains different results were obtained. For example, with silicon carbide in some arrangements of the plates compensation had to be made for difficulty encountered due to the high conductivity of silicon carbide, whereas with certain other grit particles these difficulties were not found present, such, for example, as in the use of flint.

From the foregoing it will be understood that the electrostatic field established either constantly or intermittently together with reversal of polarity between the plates 32 and 33 affects the grit particles, as they enter the electrical field, to bring them into axial alignment with the lines of force of this field. No appreciable difficulty is found to exist by the presence of the backing material 76 in the field, which would ordinarily be assumed to occur due to the setting up of extraneous electrostatic fields between the two electrodes and the backing itself, this difficulty being eliminated by the form of the electrodes, so that the major value and resultant force of the electrical field is retained.

In the more convenient form of the invention shown in Figure 9, successful results will be obtained by employing disc-like electrodes 32 and 33 of a diameter of about 8 inches, and with the opposed faces of the electrodes substantially parallel to each other.

A further form of apparatus which we may employ for carrying out this method of deposition is illustrated in Figure 10 wherein the strip, sheet or web of Figure 1 is indicated at 23, the one side of said sheet being provided with a layer 24 of adhesive material, preferably waterproof in its characteristics, though, as will be obvious, this layer of adhesive may be of the ordinary glue head type employed in the sandpaper industry for non-waterproof abrasive articles.

The sheet 23 is caused to travel in a substantially horizontal plane below a hopper 38 and between the electrodes 32 and 33 on an electrical field, the electrodes 32 and 33 being connected to an appropriate source of electrical potential of the required value. In actual practice what are known as high voltages may be required, though it will be understood that the difference of potential to be employed is subject to variation as desired for accomplishing the ultimately desired action.

For the purpose of the present disclosure the electrodes 32 and 33 form part of an electrostatic field, that is to say, a field in which a constant stress is set up but in which relatively small currents flow. Such an electrical field will be established between the electrodes 32 and 33 indicated generally by the lines of force 35. This field is set up between the electrodes 32 and 33 above the sheet 23 and below the hopper 38, and the field strength is regulated to such an extent as to act upon the abrasive particles as they are fed from the hopper 38.

The abrasive particles are shown as a cloud 39 but some of them are shown enlarged at 40 depicting the approximate positions which they assume as they fall by gravity through the electrostatic field. It will be understood that should the electrostatic field be of great enough strength, the particles issuing from the right hand end as shown in Figure 10, would be caused to orient themselves with their major axes parallel with the lines of force of the electrostatic field and be projected by that field from one of the electrodes toward the other thereof. Therefore, by regulating the electrostatic field to the desired optimum the particles will be caused merely to flatten out, and while they may, [illegible] circumstances be caused to travel [illegible] force of the field, the force [illegible] overcome their flight [illegible] charged electrode and they will fall upon the layer of adhesive, assuming positions substantially as shown in Figure 10, and indicated at 41. This orientation is more uniformly accomplished, however, in the form of the apparatus shown in Figures 8 and 9.

Inasmuch as the particles of abrasive material as they leave the hopper adjacent to the electrode 38, may in a large number of instances never reach the sheet, due to their attraction to the other electrode, we provide a movable partition 42 in the hopper, which may be adjusted transversely of the longitudinal axis of the sheet so that sand or other grit particles issuing from the hopper can be caused to issue in larger quantities from one end than from the other. A suitable handle properly insulated indicated at 43 may be employed for reciprocating the partition 42 and for adjusting same to the desired position.

In some instances the particles of grit will take on charges which may tend to cause them to induce a charge in the sheet and thus the particles would land on the sheet substantially perpendicular to the plane of said sheet. In order to avoid this as much as possible and to counteract a tendency for the particles to assume positions perpendicular to the sheet, the electrodes 32 and 33 may be supplemented by auxiliary electrodes 44 and 45 which may have a voltage regulated to exert a sufficient electrostatic field effect or action to prevent the particles from taking undesirable positions just as they strike the glue. If desired, this auxiliary field whose lines of force

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are indicated at 66, may be extended a desired distance beyond the point of actual deposition so that it will function for a period of time after the sheet has moved beyond the effect of the major electrostatic field.

Inasmuch as the poles or electrodes 36 and 44 and 37 and 46 are of like signs, there will be no tendency to set up extraneous electrostatic fields between these electrodes other than substantially ineffective electrostatic or electro-magnetic fields, as the case may be, due to difference in actual potential of the two fields 36 and 66. In any event, inasmuch as the electrostatic fields employed have their lines of force substantially parallel, the effect of any extraneous field set up between the electrodes 36 and 44 and 37 and 46 should be substantially negligible in disturbing the desired deposition and orientation of the particles on the sheet.

An illustration of one arrangement of the electrodes which will set up the desired electrical action is shown in Figure 11 in perspective. Of course in some instances it may be desired to eliminate the secondary electrostatic field 66 and by proper control of the moving partition 42 the desired results may be attained as to ultimate effect of the field on the grit particles.

Figure 11 serves to illustrate a further modified form of the hopper. In this form the hopper is of a general V-shape cross section and the bottom thereof being open is provided with a tapering slot indicated at 47. The slot is of greater dimensions at one end than at the other end so that by proper positioning of the hopper the particles of abrasive acted upon by one of the electrodes and tending to be projected toward the other thereof would be counteracted by the tapering slot in the hopper, thus preventing piling up of the abrasive grit at one margin of the sheet.

It will also be understood that by regulating the height of the hopper 46a from the sheet that different effects may be obtained to the point where the desired orientation and deposition of the grit is attained.

The electrodes 44 and 46 may be employed in Figure 11 as in Figure 10 if that be found necessary under the circumstances.

Referring now to Figure 12, the apparatus here shown discloses a hopper 56 into which the comminuted abrasive material and an adhesive material in plastic form are introduced. The hopper may be suitably heated to maintain the adhesive material in a liquid state so that it will flow from a suitable opening 60 provided in the bottom of the hopper.

As the incorporated grit and adhesive material flow from the hopper on to the sheet 23, the mass is subjected to the force of an electrostatic field 61 set up between the electrodes 62 and 64 thus orienting the particles of grit contained in the adhesive according to their electrical responsiveness to such a field, that is to say, the grits having major and minor axes, as hereinbefore pointed out, will under the influence of the electrostatic field become aligned with the lines of force 61 shown in Figure 12, while in the glue or other adhesive and thus be carried by the glue or adhesive on to the sheet where they will be deposited with their major axes substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof.

Figure 13 shows the sheet made according to the methods herein described and it will be observed that in many instances a plurality of layers of grit may be provided and for this reason a sheet such as that shown in Figure 13 is illustrated having two or more layers 41a of grit material and adhesive material deposited thereon.

In order to make clear to those skilled in the art the basic principles involved in employing the electrostatic field for the purposes of the present invention, Figures 14 to 18 have been incorporated in this case showing the various steps in development to obtain the optimum of results in deposition, distribution and orientation of the abrasive particles.

It will be understood that these Figures 14 to 18 all illustrate methods for producing deposition, distribution and orientation, but that some produce better results than others as will appear from the following description.

On reference to Figure 14, a pair of electrodes, preferably in the form of circular discs 92 and 93 are employed, one of these discs being connected to the positive side, such as at 94, of a source of difference of electrical potential and the other disc being connected to the negative side or ground as the case may be.

A relatively high difference of electrical potential was thus impressed on the two plates establishing an electrostatic field between them, into which abrasive particles 96 were introduced, either by gravity as shown in Figure 14, or by any other suitable means, so as to produce a stream of the particles as they enter the electrostatic field established between the plates 92 and 93.

This pair of substantially circular metal plates are made about 8 inches in diameter and provided with curved edges indicated at 97 and 98, thus preventing excessive concentration of the field at the edges of the plates thereby reducing the possibility of sparking between the plates.

These electrode plates were spaced about 5.5 inches apart in air and were connected to a source of electromotive force approximately 165 kilovolts, so that a substantially constant electrical potential range of about 19 kilovolts inch was maintained between them.

The mineral pulverized material (in one instance grade 80 silicon carbide) was deposited so as to fall in a stream between the two plates 92 and 93.

When either of the plates is grounded, the mineral stream which was originally at ground potential is deflected toward the ungrounded plate, so that if an adhesively coated strip was introduced between the plates 92 and 93, while orientation of the particles transversely of the strip was attained, yet deposit of mineral would take place in excess at one edge over that at another edge of the strip.

To overcome this uneven distribution of particles, the plates may be connected to the source of potential through a reversing switch or pole changer which alternately serves to connect each plate to ground and to high potential, in other words, supply an alternating voltage to said plates.

One manner of accomplishing this is disclosed in Figure 18, in which the plates 92a and 93a are connected through a pole changing apparatus 96a to a source of relatively high electrical potential, 97a.

The stream of mineral at low frequencies of reversal of polarity moved from one plate to the other following the reversals of polarity of electrical potential so that over a given period of time (say one electrical cycle) the air space be-

tween the electrodes 93a and 93c was substantially uniformly filled with mineral particles.

The source of electrical energy 97a is so arranged in this circuit that one side 98a thereof is connected to ground.

In the case of Figure 16, the plates 93b and 93d are so arranged in the circuit that one of them is connected to one of the sources of difference of potential indicated at 97b and the other to the other source indicated at 98b, the electrical centre of the sources indicated at Figure 16 being grounded as at 100. In this arrangement the main mineral stream becomes divided into two separate streams each of which tended to flow toward one of the plates thereby leaving a low mineral concentration in the space midway between the plates.

From the foregoing Figures 14, 15 and 16 it will be observed that we are enabled by adjustments and variations in the intensity of the electrical field and by its polarity and/or periodicity of change and by other adjustments, to regulate what will happen to the mineral grits as they are introduced into the electrical field. Thus where it is desirable that the grits be more heavily deposited at one portion of the adhesive coating backing than at another portion this can be regulated to a desired degree as required.

Should it be desired to prevent excess deposition of the grit in predetermined areas, then the form of the invention shown in Figure 9 and hereinabove described may be employed. For the purpose of manufacturing abrasive discs as disclosed herein this form of the invention finds utility.

In Figures 17 and 17a, a further alternative arrangement of the electrode plates is disclosed. Figure 17 being a plan view looking down on the plates, the backing element being indicated at 101 and the plates at 93c and 93c. Figure 17a is an end elevation looking inwardly in the direction indicated by the arrow A in Figure 17.

In Figures 17 and 17a we disclose the electrodes arranged in convergent planes so that the portions of the surfaces of the discs were closer together than other portions, the purpose being to further allow for adjustment in distribution of the grit particles.

The grit particles entering this electrostatic field are subjected to a variation in potential gradient from 17 k.v. inch to 34 k.v. inch, or any other variation of the electrical potential gradient, depending upon the voltages employed, size of plates, etc.

The stream of mineral is allowed to fall into the zone whose gradient is about 19 k.v. inch. There is in such circumstances apparently no tendency for the mineral particles to migrate toward the zone of high gradient, and the general dispersion and orientation of the particles is not materially interfered with and not materially different from that where the plates are substantially parallel, and the potential gradient therefore substantially uniform.

Successful results may be obtained with any of the foregoing arrangements, by the employment of an abrasive grit of a grade 1½ flint, preferably of a splintery nature.

We find that a higher electrical potential gradient may be maintained without disruptive discharge or so-called spark-over with flint, for example, than with other grits such as silicon carbide, inasmuch as in the same air space potential gradient and with the same relative quantity of grit introduced thereinto, the conductivity of silicon carbide, being higher than that of flint, tends to produce an increased tendency to spark-over or brush discharge, as it is sometimes termed, and care must in some cases be exercised to prevent the formation of a conducting path between the plates.

A method of overcoming this difficulty for certain purpose is shown in Figures 18 and 18a, wherein the two plates 93d and 93d' were arranged on opposite sides of insulating plates 102 and 103.

While the employment of these plates finds value with certain minerals, there is no marked difference in the action of the electrostatic field with other minerals, and we have found this arrangement of Figures 18 and 18a to be of value in increasing the activity of flint, but of much less perceptible value in increasing the activity of silicon carbide, inasmuch as spark-over or brush discharge sometimes occurs which causes the greater part of the applied voltage to be built up across the insulation.

The observed motion of the particles was substantially the same with or without the insulation, but, as pointed out in the case of some abrasive particles, an increased activity without a resultant brush discharge was observed. The plates also serve as a means to mechanically confine the activity of the particles to the area within the plates.

Referring now more particularly to the form of the invention shown in Figure 19, it will be observed that here may be provided a form of the apparatus wherein the electrode plates are alternately connected to ground. In this form of the invention the plates indicated at 104 and 105 are connected by conductors 106 and 107 to the negative and positive sides, respectively, of sources of electrical difference of potential 108 and 109, that is, sources of potential being connected in series as shown.

A grounding switch is provided indicated generally at 110 and has its terminals 111 and 112 thereof connected to ground as indicated at 113, switching members 114 and 115 serving to alternately connect the conductors 106 and 107 with ground.

It will be seen from the form of the invention disclosed in Figure 19 that by the alternative grounding of the plates 104 and 105, the orienting force exerted on the particle is uniformly maintained by virtue of the maintenance of a constant gradient between the plates. Dispersion of the particles thus uniformly obtained by the use of the switching arrangement prevents the bulk of the particles (which, it will be understood, are at ground potential when they pass into the zone of the plates) from being directed more to one plate than to the other.

The form of the invention shown in Figure 19 operates similarly to the form of the invention shown in Figure 9.

Reverting to the form of the invention disclosed in Figures 8 and 9, the structure there employed including a reversal of polarity does not include the insulating plates and these, under ordinary circumstances, are not required.

Under conditions shown in Figure 14 and without the use of insulation on the plates or between them, flint particles dropped into the field whose gradient was 18 k. v. inch were fairly well oriented on the sheet but the distribution is not entirely uniform.

An increase in gradient from 18 to 17.5 k. v. inch resulted in the production of a marked in-

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cross in the degree of orientation, but as well increased the inequality of distribution.

With abrasive grains of silicon carbide a limitation of the potential gradient was required so as to prevent dielectric breakdown.

The use of insulation on the plates serves to cause the mineral to be more evenly distributed, but it will be understood that some slight amount of orientation must be sacrificed owing to the slight reduction in the potential gradient caused by the employment of the insulating plates.

From the foregoing it will be observed that by adjustment of the electrostatic field value and/or adjustment of the plates with respect to the air space between them and/or their singularity with respect to each other, and/or the periodicity of polarity reversal, we are enabled to produce desired effects in the orientation and distribution of the grit particles on the sheet.

Where the particles are deposited on shingle material for the purpose of roofing shingles and the like, it will be observed that by causing them to lie flat on the adhesively coated sheets, such as an asphaltum adhesive sheet or the like, the employment of a lesser number of particles to cover a given area of the shingles is required.

Certain phases of the features of our invention dealing with the process and apparatus are claimed in our application Serial No. 200,550, filed March 31, 1938. Another phase of the process of deposition is claimed in our application Serial No. 238,612, filed June 3, 1940.

Having thus described our invention and illustrated its use, what we claim as new and desire to secure by Letters Patent is:

1. An abrasive article comprising a plurality of convolute laminations of abrasive coated material having the edges of said laminations exposed to form a substantially continuous abrading surface, the individual particles of abrasive material being held between the laminations and oriented with their longitudinal axes substantially perpendicular to said abrading surface formed by edges of said laminations and abrasive particles held thereby.

2. An abrasive article including a body formed of a convolute preformed flexible strip of adhesively anchored abrasive material having at least one edge thereof exposed to afford a substantially continuous abrading surface, the individual convolutions of said article being in relatively spaced relation to render the abrading surface flexible edgewise.

3. An abrasive article including a body formed of a convolute preformed flexible strip of adhesively anchored abrasive material, the individual convolutions of which are slightly spaced to afford clearance at the abrading surface and to render the same flexible.

4. An abrasive article including a body formed of a convolute preformed flexible strip of abrasive material, the individual convolutions of which are slightly spaced but adhesively connected to afford clearance at the abrading surface and to render the same flexible.

5. In the manufacture of abrasives, the steps which include loosely winding a strip provided with a layer of adhesive containing a grit to form a plurality of slightly spaced convolutions while the adhesive is still plastic but partially dried so as to cause the individual convolutions to adhere flexibly together to thereby form a disk-like abrading surface and to prevent displacement of the grit.

6. In the manufacture of abrasives, the steps which include forming a strip provided with a layer of adhesive containing a grit into a partially solidified state of the adhesive to fix the position of the abrasive and loosely winding the strip to form a plurality of slightly spaced convolutions while the adhesive is still plastic so as to cause the individual convolutions to adhere flexibly together to thereby form a disk-like abrading surface, and then setting the adhesive.

7. In the manufacture of abrasives, the steps which include loosely winding a strip provided with a layer of waterproof and flexible adhesive containing a grit to form a plurality of slightly spaced convolutions and while the adhesive is still plastic but in a partially dry condition so as to cause the individual convolutions to adhere flexibly together to form a disk-like abrading surface and prevent displacement of the grit from a predetermined position.

8. In the manufacture of abrasives, the steps which include securing a layer of abrasive material to a sheet or strip by a waterproof and flexible adhesive material, drying the adhesive short of final setting but sufficiently to retain the abrasive material, then winding the sheet into a convolute form to cause the individual convolutions thereof to adhere loosely together, then introducing an anchoring adhesive between said convolutions to firmly secure them into a substantially homogeneous abrasive device, then setting the adhesive finally to a flexible and waterproof condition.

9. In the manufacture of abrasives, the steps which include securing a layer of abrasive material to a sheet or strip by a waterproof and flexible adhesive material, drying the adhesive short of final setting but sufficiently to retain the abrasive material, then winding the sheet into a convolute form to cause the individual convolutions thereof to adhere loosely together, then submerging the article in an adhesive to cause the same to flow between the convolutions thereof, then setting the adhesive finally to a flexible and waterproof condition.

10. In the manufacture of abrasives, the steps which include securing a layer of abrasive material to a sheet or strip by a waterproof and flexible adhesive material, drying the adhesive short of final setting but sufficiently to retain the abrasive material, applying a sizing adhesive to said strip, then winding the sheet into a convolute form to cause the individual convolutions thereof to adhere loosely together, then setting the adhesive finally to a flexible and waterproof condition.

11. In the manufacture of abrasives, the steps which include securing a layer of abrasive material to a sheet or strip by an adhesive material, then prior to final setting of the adhesive winding the sheet into a convolute form to afford a disk-like abrading surface and to cause the majority of the individual particles of grit to become oriented with their major axes substantially perpendicular to said surface.

12. As a new article of manufacture, an abrasive implement comprising a sheeted element having a cutting edge including abrasive particles having their major axes arranged in substantial parallelism with the plane of said element and substantially perpendicular to said edge.

13. A new article of manufacture including a plurality of laminated sheeted portions marginally exposed to form an abrading surface, said portions being in superposed relation and having

abrasive particles positioned relatively to one another by electric action, substantially all of the abrasive particles at the said abrading surface having major and minor axes and being responsive to electric action, and substantially all of the particles being positioned with their major axes substantially perpendicular to said abrading surface.

14. A new article of manufacture including a plurality of laminated sheeted portions marginally exposed to form an abrading surface, said portions being in superposed relation and having abrasive particles positioned relatively to one another by electric action, substantially all of the abrasive particles at the said abrading surface having major and minor axes and being responsive to electric action, and substantially all of the particles on one of said portions being positioned with their major axes parallel with the plane of said portion and substantially perpendicular to said abrading surface.

15. As a new article of manufacture, a granular coated product comprising a sheeted element having elongated abrasive particles adhered thereon with their major axes arranged in parallelism with each other and adhered to the sheet with the major axes of said particles perpendicular to an edge of the sheet.

16. A new article of manufacture, a sheet material comprising a backing sheet having a coating of elongated granular abrasive particles adhered thereon, substantially all of said granular particles being uniformly positioned with their major axes substantially parallel to each other and to the surface of said backing sheet.

17. A new article of manufacture, a sheet material comprising a backing sheet, a coating of adhesive on one surface of said backing sheet and a coating of elongated abrasive granular material bonded to said sheet by said adhesive coating, substantially all of said granular material being uniformly oriented so that the major axes of the particles thereof are substantially parallel to each other and to the surface of said backing sheet.

18. A new article of manufacture comprising a base member having a coating of irregularly shaped and elongated abrasive particles adhered thereon, substantially all of said particles being uniformly positioned with their major axes substantially parallel to each other and to the surface of said base member.

19. As a new article of manufacture, a granular coated product comprising a sheeted element having elongated abrasive particles adhered thereon, the adjacent particles all being arranged with their major axes substantially uniformly oriented in respect to each other substantially perpendicular to one edge of said sheeted element and in parallelism with the surface of the sheet.

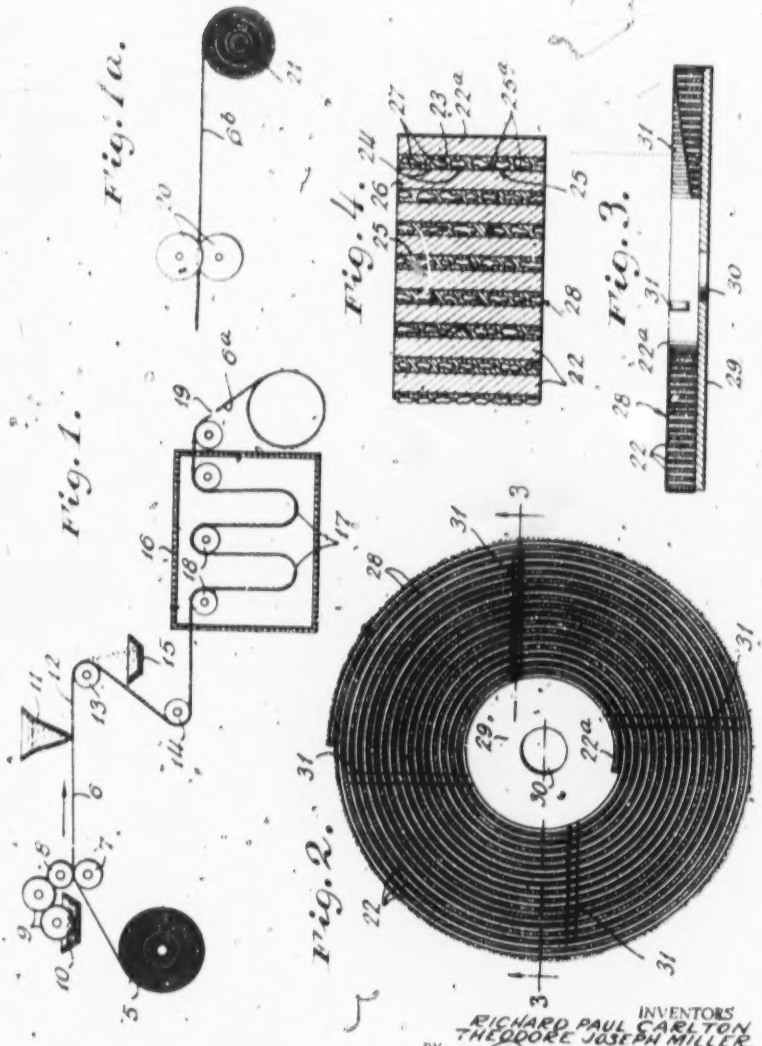
RICHARD PAUL CARLTON.
THEODORE JOSEPH MILLER.

[fol. 748]

July 8, 1941. R. P. CARLTON ET AL 2,248,853

ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Original Filed June 1, 1933 5 Sheets-Sheet 1



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July 8, 1941. R. P. CARLTON ET AL 2,248,853

ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Original Filed June 1, 1933 5 Sheets-Sheet 2

Fig. 5.

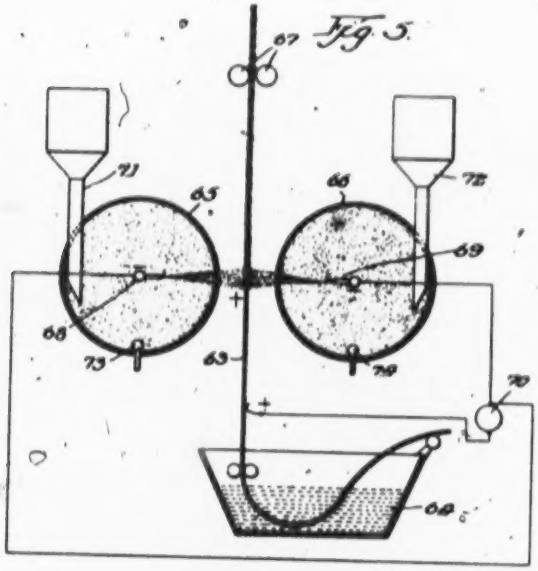

Fig. 6.

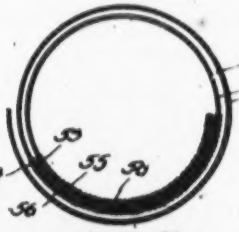

Fig. 7

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ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Original Filed June 1, 1933 5 Sheets-Sheet 3

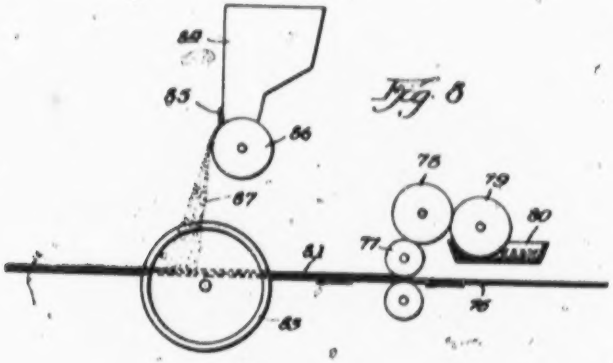

Fig. 8

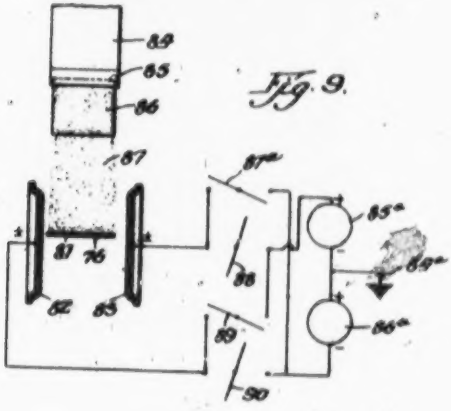

Fig. 9.

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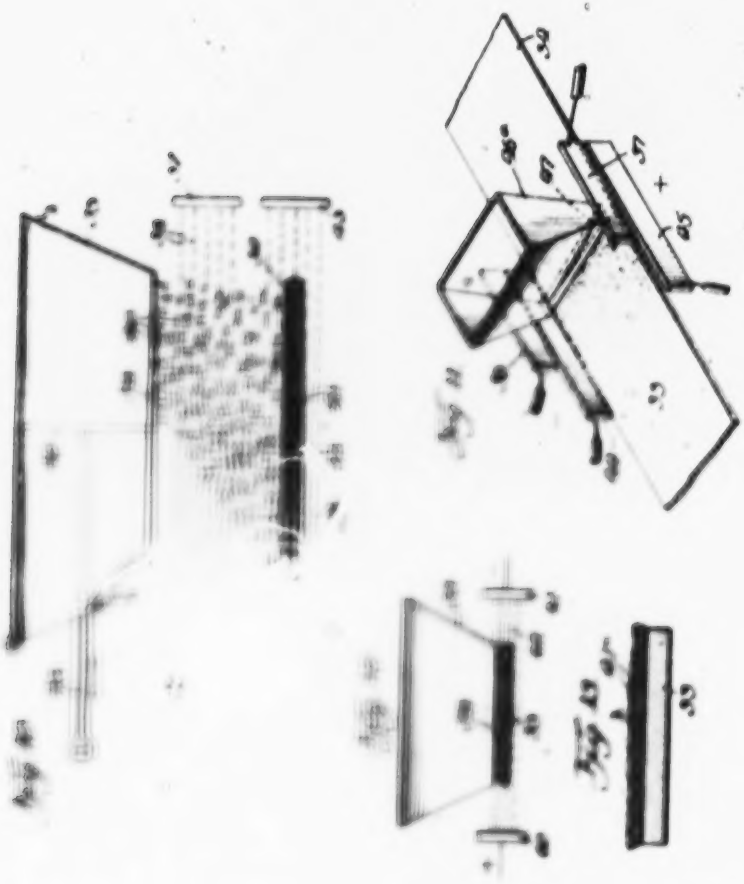
ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Original Filed June 1, 1933 5 Sheets-Sheet 4



Richard Paul Carlton
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ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Original Filed June 1, 1933 5 Sheets-Sheet 5

Fig. 14

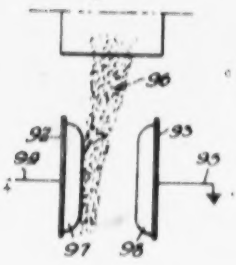


Fig. 15

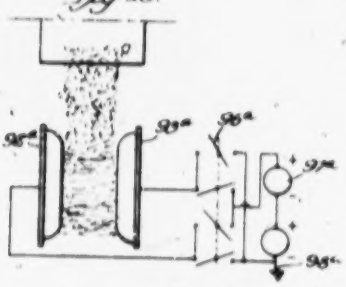


Fig. 16

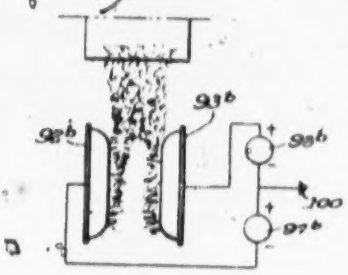


Fig. 17.

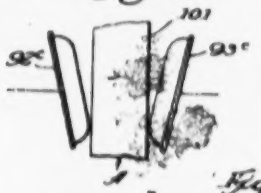
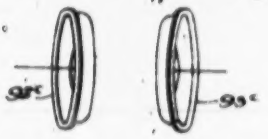


Fig. 17a



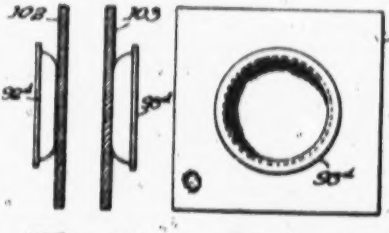
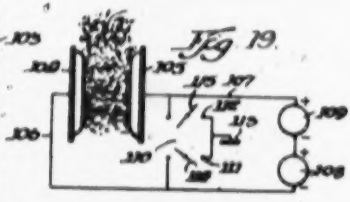


Fig. 18.

Fig. 18a.

Fig. 19



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[fol. 753]

Patented July 8, 1941

2,248,853

UNITED STATES PATENT OFFICE

2,248,853

ABRASIVE ARTICLE AND METHOD OF MAKING SAME

Richard Paul Carlton and Theodore Joseph Miller, St. Paul, Minn., assignors to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware

Original application June 1, 1933, Serial No. 673,806. Divided and this application June 3, 1940, Serial No. 338,613

3 Claims. (Cl. 51—290)

This invention relates broadly to coating and coating materials especially in sheet form, such as in the manufacture of abrasives, and the present invention among other things finds utility in one of its phases in the manufacture of abrasive wheels or discs, and while the invention in one of its forms is illustrated as adapted for coating and forming an abrasive disc, it will be understood that certain other phases of the invention are of quite general application and may be adapted for other purposes, such, for example, as a method of coating roofing material with pulverulent mineral.

This application is a division of our co-pending application, Serial No. 673,806 filed June 1, 1933.

This invention, as will hereinafter appear, finds especial utility in the production of grinding discs wherein the abrading surface is on a side thereof rather than on the periphery; and the invention also finds utility in coating roofing material so that particles of mineral deposited thereon are caused to lie flat, that is to say, with their major dimensions substantially parallel with the surface of the backing.

The customary procedure generally resorted to in the manufacture of abrasive wheels, discs and the like generally includes the mixing of an abrasive grit, such as aluminum oxide, silicon carbide or emery, with a suitable bonding material and then placing the mixture in a mold. The final setting up of the bonding material is then effected by curing at a sufficient temperature to cause the bond to flow and take a firm grip of the abrasive grit. Several different forms of the adhesive or bonding material are used, the more common being that known as a vitrified or ceramic bond. In making such a wheel it is necessary to fire the wheel, that is to say, subject the mixture of bonding material and grit to a sufficiently high temperature to cause the bonding material to flow and thus, in effect, form a porcelain bond between the various particles of grit. Obviously, such a wheel or disc is inflexible, broadly, and will not stand shock or sudden thrusts.

It has been proposed to employ as substitute bonds for the vitrified or ceramic bond, materials such as rubber, shellac, sodium silicate, natural and synthetic resins and the like.

In producing an abrasive disc or wheel, aside from the problems of choice of bond, there is also the necessity of controlling the ratio of bonding material to abrasive material, and it is also highly desirable that, in certain forms of the abrasive wheel or disc structure, more or less porosity or voids in the wheel acting as clearances for the material being abraded be provided so that fast and continuous cutting, together with reduction in temperature of the wheel when engaging the work, should be attained. In obtaining these desiderata it is found that the porosity of the wheel in the case of a molded structure tends to weaken the disc or wheel and, due to the porosity, the structure does not have sufficient bond to firmly anchor the grit therein.

The principal objects and advantages of the present invention reside in the provision of an improved method of manufacturing an abrasive wheel, disc or the like having characteristics in its structure which increase the cutting ability, strength and durability of the device; the provision of an improved method of manufacturing an abrasive article such as a wheel or disc for abrading purposes, in which the cost of manufacture is considerably reduced, with the attendant accomplishment of the desired control of ratio of bond, that is to say, adhesive, to the mineral or grit, and to provide such an improved method in which the same may be carried out as a substantially continuous process, thus simplifying the manufacture and reducing the ultimate costs; the provision of an improved method of manufacturing abrasive wheels and discs in which a fabric such as paper, cloth or the like may be employed as a carrier for the bond and grit and in which the ultimate size of the abrading wheel or disc may be determined easily and by a substantially continuous method; the provision of an improved form of abrading wheel or disc wherein a controlled porosity of the structure is obtained and wherein the ratio of adhesive material to grit is substantially uniform throughout the entire wheel or disc; the provision of an improved abrasive article such as a wheel or disc wherein the grit particles are oriented so that their most effective cutting edges are presented at the abrading surface and thus are brought into contact with the work more efficiently; the provision of an improved method of manufacturing abrasive discs, wheels and the like in which the production of the abrasive article may be carried out on existing sandpaper type of equipment, with the subsequent convenience of shortening the required time for producing various sizes of abrasive wheels and discs.

A further advantage of this invention resides in that, as distinguished from the molding process of making abrasive discs and wheels, which

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requires that the abrasive grit and bonding material be mixed in the proper ratio, then molded, then heated, and therefore requiring each separate size of wheel or batch to be handled completely individually from the beginning to the end of the entire fabrication process, the present invention permits of the carrying out of a substantially continuous process similar to the manufacture of sandpaper and that continuous lengths of the material may be stored in drums or rolls from which the desired width of strip may be cut which is to determine the ultimate thickness of the wheel, it being observed at all times that the ratio of abrasive material to bonding material will remain substantially uniform throughout the particular wheel or disc structure which it is desired to form.

The present invention also permits of the manufacture of the basic abrasive material on standard sandpaper equipment and that this material may, after having been prepared, be preserved in stabilized form for use in manufacturing wheels as desired, the process and the article thus permitting of the production of one or more wheels of a desired size and texture, that is to say, grit size or number, at less cost and more conveniently than is possible with the previous processes known to us.

It has also been suggested in the prior art that abrasive discs and wheels be made up of a series of superposed sheets of ordinary sandpaper, emery paper or cloth, or the like glued together and subjected to pressure and heat, but in such prior proces and articles, quite inconvenient known to a considerable waste occurs in that the discs must be cut from a standard made piece of sandpaper, and the portion thus made and that used must be thrown away. The present invention distinguishes from such process in that there is substantially no waste of abrasive material which is abandoned upon any dising out process, hitherto experienced.

The present invention also has as one of its objects the provision of an improved method of producing a flexible abrasive article and the resultant article so that, as desired, the manufacturer may produce an abrasive article of the desired degree of flexibility, and, at the same time, have a substantially homogeneous structure with a substantially continuous abrading surface.

The present invention also contemplates the employment therein and for the production of the abrasive articles of a new process of orienting the abrasive grains so that their sharper points will be presented at the abrading surface. In ordinary sandpaper the abrasive grains are deposited on the adhesive coated sheet by gravity and as a result lie in haphazard fashion in the adhesive.

In the present invention it is desirable that the abrasive grains be oriented so as to present the longitudinal axes of the individual particles in a position substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof so that when the abrasive article is formed from a sheet of abrasive material made according to this invention, to form an abrasive disc, the sharper points of the grains will be presented at the margins at each of the coordinations of the disc.

This orientation of the grains may be conveniently accomplished by the action of an electrical field, and it is therefore one of the further objects of this invention to provide an improved method of and apparatus for subjecting the abrasive grains to the action of an electrical field for the purpose of obtaining the desired orientation of such particles; the invention further has as one of its objects the improved method of and apparatus for subjecting the abrasive grains during the flight by gravity to the sheet to the effect of an electrical field, preferably of the electrostatic type, for aligning the particles with the lines of force of the field, which for convenience is substantially parallel with the surface of the abrasive sheet, thus orienting the grains in the proper desired manner so they are deposited thereon.

This invention also contemplated the improved method of incorporating the grit particles in an adhesive in plastic form, and while the same is deposited together with the grit on a flexible backing, subjecting the incorporated grit and adhesive to the action of an electrical field for aligning the particles and orienting the same in the desired manner.

The method involved in the present invention may be carried out in a number of alternative steps, depending upon the form and characteristics as to flexibility and dampness which it is desired to impart to the finished article.

A preferred method of producing the abrasive article of this invention includes the selection of a fabric, preferably paper, of a desired and suitable weight, coating this paper with a bonding material and a suitable grit. For our purposes we prefer to employ a waterproof bond, and, for example, this may be any of the bonds described and claimed in the patents to Ohle 1,869,827, 1,869,828, 1,869,891, Carlton 1,778,831, 1,788,-884.

This paper then coated with a waterproof bond and a suitable grit may be of the same characteristics as the waterproof sandpaper now known to the trade as "Wetordry".

The coated fabric, preferably paper, having the grit contained in the adhesive layer may be provided with a light or heavy sizing coat, depending on the use to which the material is to be applied, though in most instances a sizing coat may be omitted.

After the bond and adhesive or grit have been applied, the material is then foreseen for a sufficient period of time to dry or partially solidify the adhesive. It is preferable that the adhesive be not set to its final condition at this time but to aid in handling the adhesive should be dried to a degree which will prevent accidental displacement of the grit.

The abrasive sheet thus formed may be rolled into what are known as Jumbo rolls and may be stored until required for slitting into suitable widths. When it is desired to complete a grinding disc with this material the same may be slit to any desired width which is to be the depth of the disc or wheel and then wound into rolls of the required diameter. Owing to the fact that the adhesive material is not entirely set when the sheet is wound into a roll, the disc or wheel then formed may be placed in an oven for further drying and for completely setting up the bond.

By regulating the tension of the strip of abrasive material as it is wound into disc-like form the compactness and resultant flexibility of the final product may be desirably controlled.

It will be understood, of course, that the resultant flexibility of the article is more or less dependent upon the type of adhesive employed, and that by controlling the flexibility of the adhesive and the tension upon winding the ultimate

flexibility of the article may be regulated. As to the waterproof qualities of the article, excellent results may be obtained by employing any of the binders disclosed in the patents mentioned herein.

In the actual finished disc material this produced particularly where the strip of adhesive material is relatively loosely wound to form a disc, the convolutions thereof will afford clearance spaces, though they may at numerous points be adhering together, by virtue of the adjacent layers of the adhesive. In the actual finished article we thus are able to produce an abrading surface which has sufficient flexibility as to binder and composite to facilitate surface sanding, as it is called, and also to facilitate clearing of the wheel when it is in use.

We have found that in some cases of flexible discs or wheels it may be desirable to cement the layers or convolutions of the disc together, but this is not the preferred practice for the normal surface sanding job, and we have found that for such purposes merely winding the strip of material upon itself and then attaching it to a suitable backing, preferably flexible in nature, will produce a grinding wheel or disc giving a desirable flexibility and an efficient cutting surface.

In instances where it is desired to make a solid wheel, that is, a relatively inflexible wheel or disc it may be desirable to cement the laminations, layers or convolutions, as they may be termed, and this may be accomplished by interposing a sizing coat as the strip is wound into the disc form. It also may be desirable in some instances to apply the sizing material in a relatively heavy coating and to subject the article to heat for causing the coating to flow, and thus relatively intimately connect adjacent layers of the abrasive material.

This operation may also be accomplished when the disc is wound by immersing the same in a bath of adhesive size to permit the adhesive material to flow by capillary action between the laminations or convolutions of the disc.

One of the important factors which effect flexibility when the disc is not of the solid type is the degree of tightness of winding, and thus by relatively loosely winding the strip of adhesive material it is possible ultimately to obtain a very flexible abrasive disc.

It is important in the production of a grinding or polishing disc or wheel of the character herein disclosed that the ratio of mineral grit to adhesive be controlled to produce the most desirable coating results and also that the uniformity of this ratio throughout the disc be maintained. By the abrasive article of this invention and the method of manufacturing the same, we are enabled to attain a high degree of efficiency in cutting operations of the disc and to give to the abrasive article a substantially uniform effective abrasive surface throughout, so that as the same becomes worn in service it yet renders the same efficient cutting and/or abrading or polishing functions.

It will be understood, of course, that dependent upon the desired characteristics of the finished product, we may employ fine, medium or coarse grits and that, correspondingly, the thickness of paper or other fabric employed and the ratio of adhesive to grit or abrasive particles must be controlled in each instance to the desired degree. In certain instances we applied the adhesive and abrasive coatings to both sides of the backing.

In selecting an adhesive material, we have obtained excellent results with adhesives formed as composite materials from Bakelite, that is, phenol and formaldehyde and other, synthetic resin binders, rubber, shellac and the like, it being understood that these materials may be made into a liquid adhesive and can be further molded or softened by subsequent flowing under heat in such manner that a thorough setting or curing of the adhesive is accomplished without detracting from the flexibility thereof.

One example of an adhesive which is suitable for our purpose is that substantially according to the following formula:

	Parts
Bakelite resin	4
Thinner (denatured alcohol)	1

This composition is agitated very thoroughly until a creamy fluid possessing some tackiness is produced. This adhesive is then applied to the sheet which then receives the abrasive material.

In the case of a Bakelite resinous material the adhesive is dried after having received the mineral either on the racks or festoons or at some other point in the production of the abrasive strip, and we prefer to employ temperatures ranging from normal atmospheric room temperature to approximately 140 degrees Fahrenheit, depending on the length of time of drying. In this drying operation the temperature is maintained at such a point that the thinner or solvent only will be driven off and thus no appreciable hardening or solidifying reaction takes place in the resin at this time. When the strips are coated with this material together with a binder, heat treated as set out above and then wound into discs or wheels, they may be further subjected to heat which causes a flowing of the resinous binder and thus sufficiently unites the several convolutions or laminations of the wheel. Of course, if it is desired to make a substantially rigid wheel in this manner, same may be tightly wound and also subjected to pressure as well as heat subsequently.

When employing a synthetic resinous material such as a Bakelite resin, the same is thinned with a suitable thinner and coated on the sheet in the same manner as that employed in conventionally forming sandpaper. The grit is then applied as quickly after the binder application as may be practicable. The thinners are evaporated at normal temperatures, and the bond thereupon solidifies to the consistency of a varnish partially dried but tack free.

The abrasive article in this condition may then be stored in large rolls and cut or slit into ribbon disc portions as required.

In order to insure flexibility of the abrasive article during handling, it is preferred that the rolls be stored in a humid atmosphere, so that the article will be possessed of flexibility during the heating operation.

After the abrasive material is cut and formed into ribbon discs, the bond may be toughened by further heat treatment at, say, 180 to 185 degrees Fahrenheit for approximately fifteen minutes, which produces a flexible consistency and is suitable for some purposes, or, we may employ temperatures ranging from 250 to 300 degrees Fahrenheit for a period of time of from fifteen minutes to one hour to produce a relatively hard bond in which there is substantially no flexibility in the binder coat itself. Where a

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flexible binding coat is desired, a proper regulation of the temperatures and employment of suitable modifiers in the Bakelite resin will give satisfactory results.

It will be understood that the preference to storing the abrasive in large rolls, jumbo rolls, as they are called, is that sometimes it is difficult to synchronize the heating operation with the drying festoons, and for some purposes it is preferred that the abrasive sheet as it is formed be placed in jumbo rolls so that it may be slit to the desired widths as required.

In connection with the foregoing formula we have secured a flexible abrasive strip to be wound into a disc or wheel shape by employing a Bakelite material which does not produce a complete reaction to rigidity or by keeping the temperature below 212° F. and reducing the time of heat treatment.

For the purposes of this invention we prefer to employ a flexible binding material on the flexible backing, but it is to be understood that a satisfactory flexible wheel or disc may be produced employing a relatively less flexible binder by keeping the layers or laminations of the wheel separated.

We have made satisfactory abrasive wheels or discs by employing an adhesive of the varnish type such as is disclosed in the patents to Okie hereinabove referred to, and we have also employed as a binder the material disclosed in the application of Carlton and Okie, Serial No. 688,319.

Where rubber, shellac or synthetic resins other than Bakelite are employed, we also prefer to heat treat the same in the final setting or, if necessary after first applying the binder to the strip which is to be later wound into the disc form. With rubber, sulphur is added in desired amount to the adhesive material so that the vulcanization of the binder takes place in the heating step.

Under some circumstances, in order to prevent starving of the bond between the grit and the sheet, it is desirable to apply sizing coat to the back of the sheet, and this may be done during the winding of the sheet or after the original process of making the sheet simultaneously with the application of the adhesive and grit.

The outstanding advantages of the present invention, particularly where the same is wound into a roll to form a disc or wheel, reside in that we are enabled to produce a laminated abrasive structure in which the abrading surface presents a more definite and more uniform porosity due to the laminations and due to the spot contacting of the adhesive on one layer with the adjacent layer, and thus producing a greater proportion of voids than is possible or obtainable where abrasive grit and a bond are molded even where equal ratios of bond to grit are employed. Our invention also produces a laminated abrasive structure having an increased strength due to the incorporation therein of the coated backing of fabric such as paper or cloth, which adds to the strength of the entire wheel making the same less brittle and more flexible and permitting of thinner wheels to be prepared than by any other prior method known to us.

Another distinct advantage of our invention resides in the fact that the mineral grits, owing to their elongated nature, may be oriented on the abrading device so that their sharp points are presented at the abrading surface. For some purposes it is desirable to deposit the abrasive grit by an electrical field or other electrical action, such as by an electrostatic field, in such a manner that the grits will become oriented with their major axes parallel to the surface of the sheet and perpendicular to the abrading surface, particularly where the grits are placed so that their major axes are perpendicular to the margins of the strip from which the wheel is wound. We shall describe such a process of deposition of the grits more fully hereinafter.

It will be understood, of course, that after the abrasive strip has been wound to the desired diameter and with the desired degree of tightness, a suitable disc backing may be affixed by a waterproof binder if desired on one surface of the resultant abrasive disc so that the disc may be mounted on a suitable shaft for imparting rotation thereto.

The several methods which may be employed in the manufacture of the abrasive article itself are illustrated in the accompanying drawings, in which—

Figure 1 is a schematic view of an apparatus which may be employed for producing the abrasive article of this invention.

Figure 1a is a schematic view of a slitting and winding apparatus which may be used with the apparatus shown in Figure 1.

Figure 2 is a plan view of an abrasive disc made according to this invention.

Figure 3 is a transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 4 is an enlarged transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 5 is a schematic view of apparatus for coating one or both sides of the abrasive article.

Figures 6 and 7 are fragmentary sectional views of an alternative form of an abrasive article made according to this invention.

Figure 8 is a schematic view of an alternative form of apparatus for securing orientation of the abrasive particles.

Figure 9 is a view showing the apparatus of Figure 8 from another aspect.

Figure 10 is an elevational schematic view illustrating alternative apparatus for carrying out the step of orientation of the abrasive particles.

Figure 11 is a perspective view of an alternative form of apparatus of this invention.

Figure 12 is an elevational view of a still further modified form of the invention.

Figure 13 is an enlarged sectional view of a sheet illustrating the alignment of the abrasive grains thereon.

Figures 14, 15, 16, 17, 17a, 18, 18a and 19 are all diagrammatic views of alternative forms of the invention shown in Figures 8 and 9.

Referring now more particularly to the drawings, and first to Figure 1, there is shown a roll of fabric such as paper or cloth 6, from which the web 6 is unwound over an idler roller 7, to receive from a coating roll 8 a layer of the adhesive material delivered by the series of feed rolls 9 from a tank 10. The web 6 is fed beneath a hopper 11 from which is supplied a quantity of comminuted abrasive material 12 by gravity, which may be suitably regulated in any desired manner to determine the thickness of the grit layer. The positioning of the abrasive material may be controlled at this point by the use of electrical orienting apparatus as shown in Figure 8 and hereafter more fully described. The

sheet or web 6 is then trained over a roll 13 and reflexively bent upon itself by a roll 14, some of the grit in excess of that desired being removed by falling by gravity into a container 15. The web 6 with the layer of grit secured thereto by an adhesive, waterproof if desired, is then fed into a drying room or oven 16, and arranged in festoons 17 by the provision of rolls 18 in said drying room.

The temperature of the drying room is maintained at a degree which will only partially set the adhesive sufficiently to permit handling of the abrasive coated strip or sheet indicated at 6a as it leaves the drying room. At this point Figure 1 shows the sheet as broken, indicated at 19, inasmuch as it may be desired to store the resultant product at this point before continuing the same to the slitting apparatus. However, if it is desired to have a continuous making process, then the sheet or web is supplied to slitting apparatus represented by the cutting knives 20, as shown in Figure 1a. These knives may be arranged at any convenient distance apart, depending on the width or thickness of the strip to be cut and ultimately wound into the abrasive disc.

From the slitting apparatus the several resultant strips of abrasive sheet material may be fed to a mandril 21, on which they may be wound into the final abrasive disc elements producing the articles such as shown in Figures 2, 3 and 4.

It will be understood that while the strip shown at 6b in Figures 1 and 1a is wound with the abrasive coated side outwardly, thus leaving an outer abrasive coated surface exposed at the last convolution, the disc may be as readily wound in the opposite direction so that the abrasive coated surface of each lamination will be presented inwardly. Inasmuch as these discs are intended to grind on one of their side faces, and as a substantially continuous abrasive coated surface is thus afforded, the discs may be wound either way desired.

It is also to be understood that by placing the strip 6b under more or less tension as desired, a tighter or looser wound disc may be obtained.

When the abrasive material is deposited by gravity as shown in Figure 1, it will be understood that the abrasive grains will be largely lying haphazard on the abrasive surface, though a large number of them will be oriented by the contact of the freshly coated surface with the roll 14 so that when the strip 6b is wound into a roll to form the disc the grains will be knocked down in such a manner that their sharper points will, as the disc is employed in grinding or polishing the surface, be brought against the surface of the work. However, to insure that the majority of the grits will be so oriented, we have provided methods and apparatus for so orienting the grains which will be described more fully hereinafter.

Figures 2, 3 and 4 illustrate a disc made according to this invention, wherein the disc is composed of a plurality of convolutions 22 of abrasive coated material affording a laminated abrasive structure. The laminations are held together by the adhesive material establishing contact on one convolution with the back surface of the adjacent convolution so that a structure somewhat similar to Figure 4 will be obtained, the innermost convolution 22a having its coating 23 of adhesive material contacting at a plurality of points, indicated at 24—24 with the back surface 25 of the immediately adjacent convolution 26. Thus the abrasive grains indicated at 27 in the layer of adhesive 23 are substantially embedded therein with their major axes and thus their sharper cutting points presented toward the margins of the laminations. In this way a substantially continuous abrading surface indicated at 28 on the surface of the disc is thus provided. It will be understood that care must be exercised that the proper weight of paper with regard to abrasive and adhesive be selected.

The disc-like structure thus provided may be secured to a flexible backing 29 of paper or cloth or other suitable material having an axial opening 30 by which the same may be attached to the rotating shaft of a grinding machine.

It will be understood that the backing 29 should be cemented to the disc by a flexible waterproof adhesive similar to that employed in the disc itself, or, if desired for some purposes, the backing 29 may be of a rigid material and the disc likewise cemented thereto.

In Figure 4, it will be understood, of course, that the thicknesses of the convolutions and layers of grit and adhesive have been greatly exaggerated in size, although it is conceivable that one might produce an abrasive article having convolutions whose thicknesses are as great as those shown in Figure 4. However, in the ordinary form of the invention for employment in standard surface grinding the disc is made up of a sheet not substantially greater in thickness than a sheet of ordinary sandpaper, thus lending to the final product a desired degree of flexibility.

It will be observed that in some instances it may be desirable to provide grooves in the abrading surface 28, these grooves being shown at 31 in Figures 2 and 3. It will also be noted that the grooves 31 are preferably of greater depths at their inner ends toward the axis of the disc than at their outer ends adjacent to the periphery of the disc. These grooves may be formed in the disc after the fabrication of the same inasmuch as forming the grooves in the strip prior to finally winding would require considerable care in aligning the notches in each convolution from which these grooves are formed.

The disc thus formed contains a number of voids which are afforded by virtue of the grit particles themselves holding the laminations apart and by the vacant places indicated at 32a where the glue or other adhesive does not completely fill the spaces between the convolutions. Thus the abrasive article quickly cleans itself as it works and clogging or loading of the article is practically impossible.

We have found that a satisfactory grinding and polishing wheel may be constructed by methods disclosed herein, and in one form of the invention, which is illustrated in Figures 6 and 7, we apply a coating of adhesive material containing an abrasive to both sides of the strip forming the flexible abrasive article. This coating operation may be accomplished by the apparatus shown in Figure 5.

After making a double coated strip, it is then wound loosely into a configuration substantially like that shown in Figures 6 and 7. The thus wound material is then thoroughly cured and dried. After curing, the disc-like structure then afforded is cemented to the cloth backing in such a manner as to preserve the open or spaced convoluted structure as shown. The polishing compound, which may be according to the formula appearing below, is then forced into the

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spaces between the layers and when completely filled with polish the disc is then allowed to set for sufficient time to solidify the polish base. This drying time, we find to give best results by subjecting the article to a drying temperature for approximately forty-eight hours.

A satisfactory formula which we have employed for the purpose of compounding the polishing material may be as follows:

	Grams
Nitro base thinned to 50% solids	200
Dibutyl phthalate	4.0
400 silicon carbide	40.0
Tripoli	150.0
Borax	16.0
Erkalin	4.0

From the foregoing it will be observed that we produce a convoluted structure indicated generally at 80, composed of the laminations of the convolutions 81 of suitable fabric coated on both sides as indicated at 83 and 84 with adhesive 85 containing the comminuted abrasive material 86. It will be noted that sufficient space is afforded between the layers 81 particularly as shown in Figure 7 to permit of the introduction of a comminuted polishing material indicated at 87. Thus the finished article possesses both grinding and polishing properties.

It will be understood that it is highly desirable that the comminuted abrasive material be disposed on the strip or sheet in such manner that the individual grits will have their major axes preferably lying parallel with the surface of the sheet, and, where the sheet is to be wound later to form a disc which marginally exposes an edge of the sheet for forming the abrasive surface, that the grits be perpendicular or substantially perpendicular to the longitudinal margins of the sheet.

While orientation of the grits with their major axes parallel with the surface of the sheet and substantially perpendicular to the edges thereof, may be more or less accomplished in simple gravity deposition of the grits on the adhesive coated sheet, a positive orientation of the individual grains may be accomplished by electrical action, that is to say, the grits may be deposited on the sheet in the presence of an electrical field, for example electrostatic, or if the grit particles are of a magnetically responsive nature then in the presence of an electro-magnetic field. Grits deposited in the presence of such an electrical field will be caused to align themselves with the lines of force of the electro-magnetic or electrostatic field as the case may be.

For most abrasive articles an electrostatic field will perform the function inasmuch as most of the grit particles commonly employed in the abrasive arts are of a non-magnetic character and are non-conductors and practically all will respond to the force of an electrostatic field.

Referring specifically to Figure 5, we provide a suitable backing for carrier strip 82 which receives coats of adhesive material on both sides thereof from a suitable tank 84, the strip being conducted upwardly between two chambers 85 and 86 and then conducted through edge guide rollers 87.

In the chambers 85 and 86 there are provided electrodes 88 and 89 of preferably negative polarity, the sheet being itself of a conductive nature and connected to the positive side of a source of electric motive force indicated at 70.

The apparatus receives grit from hoppers 71 and 72 which is agitated in the form of clouds within the chambers 85 and 86 by air blasts introduced at the nozzles 73 and 74.

The apparatus shown in Figure 5 is similar to that shown in the patent to Smyser 1,788,600, and serves to illustrate one apparatus for carrying out the double coating simultaneously. This form of the apparatus does not, however, produce orientation of the grit particles with their major axes parallel to the plane of the sheet, and reference will be made hereinafter to forms of the invention including apparatus for this purpose.

It will be understood that the sheet may be coated on both sides by running it twice through either a gravity coating apparatus or any of the apparatus shown in the other figures of the drawings.

As herein pointed out, it is desirable to orient the grit particles so that they will lie with their major axes substantially parallel to the surface to be coated, and they will thus present their sharp points at the edges of the strip as the same becomes worn in use as an abrading disc.

This orientation of the particles uniformly on the sheet is also of utility in the manufacture of mineral coated shingles wherein it is desirable that the particles of mineral, granules or the like, be deposited so that a minimum number of the mineral granules is required to cover a given area of the asphaltum sheet or other material from which the carrier or backing of the shingle is made.

We have illustrated herein a number of ways in which this may be accomplished which are all included in the disclosures of Figures 8 to 12, both inclusive, and Figures 14 to 16, both inclusive, it being understood that these electrical orienting devices are to be used in the general apparatus shown in Figures 1 and 1a at the point indicated by the hopper 11.

With reference first to Figures 8 and 9, we have employed a backing 76, of suitable material which receives a coating on the upper surface of the horizontal flight thereof, shown in Figure 8, this coating being applied from a set of adhesive distributing or applying rollers 77, 78 and 79, the latter taking up adhesive from a tank 80. This adhesive layer is indicated at 81 and the backing is then propelled to the left as viewed in Figure 8 between electrodes forming an electrostatic field.

These electrodes, we have found, may conveniently comprise a pair of circular disc-like plates 82 and 83, between which the horizontal flight of paper 76 passes at a desired rate of speed. Other forms of the plate electrodes may be employed, but we have found that this type produces a uniform field and highly satisfactory performance.

Above the flight 76, and at a distance sufficiently remote from the electrodes so as to be substantially unaffected thereby, we provide a hopper 84, which may contain abrasive grains of the desired size. We find that for our apparatus an abrasive grain or pulvule of a slivery character that is somewhat elongated, will give highly desirable results as to orientation, though it will be understood that it is not necessary that this type of pulverulent material be employed in order to attain the results of this invention. Practically all of the grits employed in the abrasive industry today are characterized by having a major and a minor axis so that they become responsive to the action of an electrical field when introduced into the presence of the same.

These grits are deposited by gravity from a

hopper 84 having a suitable controlling gate 85 over a distributing roller 86 so that they fall in a substantially continuous stream 87 toward the adhesive surface 81, passing between the electrodes 82 and 83 in their path to the adhesive surface.

We have discovered that a static electrical field solely, that is to say, without outside influence, mechanical or otherwise, acting upon the grit particles, tends to deflect them toward one of the plates, and in order to correct this and produce a more uniform distribution and yet obtain orientation, we employ a pole changer, diagrammatically illustrated in Figure 9, through which the two electrodes 82 and 83 are connected to the source of electrical difference of potential.

A source of electromotive force, preferably of relatively high voltage, is provided. The voltage employed in one arrangement of the electrodes was about 105 kilovolts and in employing this voltage the plates or electrodes were spaced about 5.5 inches apart in air. This arrangement served to maintain a constant electrical potential gradient of approximately 19 kilovolts per inch between the electrodes.

In correcting for uneven distribution, the electrical center of the source of difference of potential is grounded as indicated at 84a in Figure 9, and the source composed of two units 85a and 86a is so connected through pole changing switches 87a, 88, 89 and 90 that the relative polarity of the two plates 82 and 83 forming the electrostatic field was changed at a desired frequency.

We have found that, for our purposes, with the plates spaced between 5 and 6 inches apart in air, the best results are obtained by the use of electrical potential gradients of the range of from 17 to 20 k. v. per inch. We also find that where reversal of polarity is resorted to, as in the disclosure in Figure 9, the optimum of frequency of polarity change or reversal should be in the vicinity of two cycles per second. However, we have found that ranges of from one cycle per second to four cycles per second produce satisfactory results and that little change was noted in thereby producing satisfactory distribution and orientation of grit particles on the sheet.

It will be understood that the foregoing disclosure of values as to voltages, rates of polarity change, and size of and distance between the plates is all subject to variation to suit the particular conditions and results to be attained thereby.

We have also found that with different types of abrasive grains different results were obtained. For example, with silicon carbide in some arrangements of the plates compensation had to be made for difficulty encountered due to the high conductivity of silicon carbide, where as with certain other grit particles these difficulties were not found present, such, for example, as in the use of flint.

From the foregoing it will be understood that the electrostatic field established either constantly or intermittently together with reversal of polarity between the plates 82 and 83 affects the grit particles, as they enter the electrical field, to bring them into axial alignment with the lines of force of this field. No appreciable difficulty is found to exist by the presence of the backing material 76 in the field, which would ordinarily be assumed to occur due to the setting up of extraneous electrostatic fields between the two electrodes and the backing itself, this difficulty being eliminated by the form of the electrodes, so that the major value and resultant force of the electrical field is retained.

In the more convenient form of the invention shown in Figure 9, successful results will be obtained by employing disc-like electrodes 82 and 83 of a diameter of about 8 inches, and with the opposed faces of the electrodes substantially parallel to each other

A further form of apparatus which we may employ for carrying out this method of deposition is illustrated in Figure 10 wherein the strip, sheet or web of Figure 1 is indicated at 32, the one side of said sheet being provided with a layer 34 of adhesive material, preferably waterproof in its characteristics, though, as will be obvious, this layer of adhesive may be of the ordinary glue bond type employed in the sandpaper industry for non-waterproof abrasive articles.

The sheet 32 is caused to travel in a substantially horizontal plane below a hopper 35 and between the electrodes 36 and 37 of an electrical field, the electrodes 36 and 37 being connected to an appropriate source of electrical potential of the required value. In actual practice what are known as high voltages may be required, though it will be understood that the difference of potential to be employed is subject to variation as desired for accomplishing the ultimate desired action.

For the purpose of the present disclosure the electrodes 36 and 37 form part of an electrostatic field, that is to say, a field in which a constant stress is set up but in which relatively small currents flow. Such an electrical field will be established between the electrodes 36 and 37 indicated generally by the lines of force 38. This field is set up between the electrodes 36 and 37 above the sheet 32 and below the hopper 35, and the field strength is regulated to such an extent as to act upon the abrasive particles as they are fed from the hopper 35.

The abrasive particles are shown as a cloud 39 but some of them are shown enlarged at 40 depicting the approximate positions which they assume as they fall by gravity through the electrostatic field. It will be understood that should the electrostatic field be of great enough strength, the particles issuing from the right hand end as shown in Figure 10, would be caused to orient themselves with their major axes parallel with the lines of force of the electrostatic field and be projected by that field from one of the electrodes toward the other thereof. Therefore, by regulating the electrostatic field to the desired optimum the particles will be caused merely to flatten out, and while they may, under these circumstances be caused to travel along the lines of force of the field, the force of gravity will tend to overcome their flight toward the oppositely charged electrode and they will fall upon the layer of adhesive, assuming positions substantially as shown in Figure 10, and indicated at 41. This orientation is more uniformly accomplished, however, in the form of the apparatus shown in Figures 8 and 9.

Inasmuch as the particles of abrasive material as they leave the hopper adjacent to the electrode 36, may in a large number of instances never reach the sheet, due to their attraction to the other electrode, we provide a movable partition 42 in the hopper, which may be adjusted transversely of the longitudinal axis of the sheet

so that the length of the slot in the bottom of the hopper may be varied to cause the grit particles to issue through only a portion of said slot. A suitable handle properly insulated indicated at 43 may be employed for reciprocating the partition 42 and for adjusting same to the desired position.

In some instances the particles of grit will take on charges which may tend to cause them to induce a charge in the sheet and thus the particles would land on the sheet substantially perpendicular to the plane of said sheet. In order to avoid this as much as possible and to counteract a tendency for the particles to assume positions perpendicular to the sheet, the electrodes 36 and 37 may be supplemented by auxiliary electrodes 44 and 45 which may have voltage regulated (by means not shown) to exert a sufficient electrostatic field effect or action to prevent the particles from taking undesirable positions just as they strike the glue. If desired, this auxiliary field whose lines of force are indicated at 46, may be extended a desired distance beyond the point of actual deposition so that it will function for a period of time after the sheet has moved beyond the effect of the major electrostatic field.

Inasmuch as the poles or electrodes 36 and 44 and 37 and 45 are of like signs, there will be no tendency to set up extraneous electrostatic fields between these electrodes other than substantially ineffective electrostatic or electro-magnetic fields, as the case may be, due to difference in actual potential of the two fields 38 and 46. In any event, inasmuch as the electrostatic fields employed have their lines of force substantially parallel, the effect of any extraneous field set up between the electrodes 36 and 44 and 37 and 45 should be substantially negligible in disturbing the desired deposition and orientation of the particles on the sheet.

An illustration of one arrangement of the electrodes which will set up the desired electrical action is shown in Figure 11 in perspective. Of course in some instances it may be desired to eliminate the secondary electrostatic field 46 and by proper control of the moving partition 42 the desired results may be attained as to ultimate effect of the field on the grit particles.

Figure 11 serves to illustrate a further modified form of the hopper. In this form the hopper is of a general v-shape cross section and the bottom thereof being open is provided with a tapering slot indicated at 47. The slot is of greater dimensions at one end than at the other end so that by proper positioning of the hopper the particles of abrasive acted upon by one of the electrodes and tending to be projected toward the other thereof would be counteracted by the tapering slot in the hopper, thus preventing piling up of the abrasive grit at one margin of the sheet.

It will also be understood that by regulating the height of the hopper 48a from the sheet that different effects may be obtained to the point where the desired orientation and deposition of the grit is attained.

The electrodes 44 and 45 may be employed in Figure 11 as in Figure 10 if that be found necessary under the circumstances.

Referring now to Figure 12, the apparatus here shown discloses a hopper 58 into which the comminuted abrasive material and an adhesive material in plastic form are introduced. The hopper may be suitably heated to maintain the adhesive material in a liquid state so that it will flow from a suitable opening 59 provided in the bottom of the hopper.

As the incorporated grit and adhesive material flow from the hopper onto the sheet 33, the mass is subjected to the force of an electrostatic field 62 set up between the electrodes 60 and 61 thus orienting the particles of grit contained in the adhesive according to their electrical responsiveness to such a field, that is to say, the grits having major and minor axes, as hereinbefore pointed out, will under the influence of the electrostatic field become aligned with the lines of force 62 shown in Figure 12, while in the glue or other adhesive and thus be carried by the glue or adhesive on to the sheet where they will be deposited with their major axes substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof.

Figure 13 shows the sheet made according to the methods herein described and it will be observed that in many instanecs a plurality of layers of grit may be provided and for this reason a sheet such as that shown in Figure 13 is illustrated having two or more layers 61a of grit material and adhesive material deposited thereon.

In order to make clear to those skilled in the art the basic principles involved in employing the electrostatic field for the purposes of the present invention, Figures 14 to 18 have been incorporated in this disclosure showing the various steps in development to obtain the optimum of results in deposition, distribution and orientation of the abrasive particles.

It will be understood that these Figures 14 to 18 all illustrate methods for producing deposition, distribution and orientation, but that some produce better results than others as will appear from the following description.

On reference to Figure 14, a pair of electrodes, preferably in the form of circular discs 92 and 93 are employed, one of these discs being connected to the positive side, such as at 94, of a source of difference of electrical potential and the other disc being connected to the negative side or ground as the case may be.

A relatively high difference of electrical potential was thus impressed on the two plates establishing an electrostatic field between them, into which abrasive particles 96 were introduced, either by gravity as shown in Figure 14, or by any other suitable means, so as to produce a stream of the particles as they enter the electrostatic field established between the plates 92 and 93.

This pair of substantially circular metal plates are made about 8 inches in diameter and provided with curved edges indicated at 97 and 98, thus preventing excessive concentration of the field at the edges of the plates thereby reducing the possibility of sparking between the plates. These electrode plates were spaced about 5.5 inches apart in air and were connected to a source of electromotive force approximately 105 kilovolts, so that a substantially constant electrical potential range of about 19 kilovolts per inch was maintained between them.

The mineral pulverized material (in one instance grade 80 silicon carbide) was deposited so as to fall in a stream between the two plates 92 and 93.

When either of the plates is grounded, the mineral stream which was originally at ground potential is deflected toward the ungrounded plate, so that if an adhesively coated strip was introduced between the plates 92 and 93, while orientation of the particles transversely of the

strip was attained, yet deposit of mineral would take place in excess at one edge over that at another edge of the strip.

To overcome this uneven distribution of particles, the plates may be connected to the source of potential through a reversing switch or pole changer which alternately serves to connect each plate to ground and to high potential, in other words, supply an alternating voltage to said plates.

One manner of accomplishing this is disclosed in Figure 15, in which the plates 93a and 93c are connected through a pole changing apparatus 96a to a source of relatively high electrical potential, 97.

The stream of mineral at low frequencies of reversal of polarity moved from one plate to the other following the reversals of polarity of electrical potential so that over a given period of time (say one electrical cycle) the air space between the electrodes 93a and 93c was substantially uniformly filled with mineral particles.

The source of electrical energy 97a is so arranged in this circuit that one side 98a thereof is connected to ground.

In the case of Figure 16, the plates 93b and 93b are so arranged in the circuit that one of them is connected to one of the sources of difference of potential indicated at 97b and the other to the other source indicated at 98b, the electrical centre of the sources indicated at Figure 16 being grounded as at 100. In this arrangement the main mineral stream becomes divided into two separate streams each of which tended to flow toward one of the plates thereby leaving a low mineral concentration in the space midway between the plates.

From the foregoing Figures 14, 15 and 16 it will be observed that we are enabled by adjustments and variations in the intensity of the electrical field and by its polarity and/or periodicity of change and by other adjustments, to regulate what will happen to the mineral grits as they are introduced into the electrical field. Thus where it is desirable that the grits be more heavily deposited at one portion of the adhesive coating backing than at another portion this can be regulated to a desired degree as required.

Should it be desired to prevent excess deposition of the grit in predetermined areas, then the form of the invention shown in Figure 9 and hereinabove described may be employed. For the purpose of manufacturing abrasive discs as disclosed herein this form of the invention finds utility.

In Figures 17 and 17a, a further alternative arrangement of the electrode plates is disclosed, Figure 17 being a view looking down on the plates, the backing element being indicated at 101 and the plates at 93c and 93c. Figure 17a is a view looking inwardly in the direction indicated by the arrow A.

In Figures 17 and 17a we disclose the electrodes arranged in convergent planes so that some portions of the surfaces of the discs were closer together than other portions, the purpose being to further allow for adjustment in distribution of the grit particles.

The grit particles entering this electrostatic field are subjected to a variation in potential gradient from 17 k. v. per inch to 34 k. v. per inch, or any other variation of the electrical potential gradient, depending upon the voltages employed, size of plates, etc.

The stream of mineral is allowed to fall into the zone whose gradient is about 19 k. v. per inch. There is in such circumstances apparently no tendency for the mineral particles to migrate toward the zone of high gradient, and the general dispersion and orientation of the particles is not materially interfered with and not materially different from that where the plates are substantially parallel, and the potential gradient therefore substantially uniform.

Successful results may be obtained with any of the foregoing arrangements, by the employment of an abrasive grit of a grade 1½ flint, preferably of a splintery nature.

We find that a higher electrical potential gradient may be maintained without disruptive discharge or so-called spark-over with flint, for example, than with other grits such as silicon carbide, inasmuch as in the same air space potential gradient and with the same relative quantity of grit introduced thereinto, the conductivity of silicon carbide, being higher than that of flint, tends to produce an increased tendency to spark-over or brush discharge, as it is sometimes termed, and care must in some cases be exercised to prevent the formation of a conducting path between the plates.

A method of overcoming this difficulty for certain purposes is shown in Figures 18 and 18a, wherein the two plates 93d and 93d were arranged on opposite sides of insulating plates 102 and 103.

While the employment of these plates finds value with certain minerals, there is no marked difference in the action of the electrostatic field with other minerals, and we have found this arrangement of Figures 18 and 18a to be of value in increasing the activity of flint, but of much less perceptible value in increasing the activity of silicon carbide, inasmuch as spark-over or brush discharge sometimes occurs which causes the greater part of the applied voltage to be built up across the insulation.

The observed motion of the particles was substantially the same with or without the insulation, but, as pointed out in the case of some abrasive particles, an increased activity without a resultant brush discharge was observed. The plates also serve as a means to mechanically confine the activity of the particles to the area within the plates.

Referring now more particularly to the form of the invention shown in Figure 19, it will be observed that here may be provided a form of the apparatus wherein the electrode plates are alternately connected to ground. In this form of the invention the plates indicated at 104 and 105 are connected by conductors 106 and 107 to the negative and positive sides, respectively, of sources of electrical difference of potential 108 and 109, that is, sources of potential being connected in series as shown.

A grounding switch is provided indicated generally at 110 and has its terminals 111 and 112 thereof connected to ground as indicated at 113, switching members 114 and 115 serving to alternately connect the conductors 106 and 107 with ground.

It will be seen from the form of the invention disclosed in Figure 19 that by the alternative grounding of the plates 104 and 105, the orienting force exerted on the particle is uniformly maintained by virtue of the maintenance of a constant gradient between the plates. Dispersion of the particles thus uniformly obtained by the use of the switching arrangement prevents

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the bulk of the particles (which, it will be understood, are at ground potential when they pass into the zone of the plates) from being directed more to one plate than to the other.

The form of the invention shown in Figure 19 operates similarly to the form of the invention shown in Figure 9.

Reverting to the form of the invention disclosed in Figures 8 and 9, the structure there employed including a reversal of polarity does not include the insulating plates and these, under ordinary circumstances, are not required.

Under conditions shown in Figure 14 and without the use of insulation on the plates or between them, flint particles dropped into the field whose gradient was 18 k. v. per inch were fairly well oriented on the sheet but the distribution is not entirely uniform.

An increase in gradient from 18 to 17.5 k. v. per inch resulted in the production of a marked increase in the degree of orientation, but as well increased the inequality of distribution.

With abrasive grains of silicon carbide a limitation of the potential gradient was required so as to prevent dielectric breakdown.

The use of insulation on the plates serves to cause the mineral to be more evenly distributed, but it will be understood that some slight amount of orientation must be sacrificed owing to the slight reduction in the potential gradient caused by the employment of the insulating plates.

From the foregoing it will be observed that by adjustment of the electrostatic field value and/or adjustment of the plates with respect to the air space between them and/or their angularity with respect to each other, and/or the periodicity of polarity reversal, we are enabled to produce desired effects in the orientation and distribution of the grit particles on the sheet.

Where the particles are deposited on shingle material for the purpose of roofing shingles and the like, it will be observed that by causing them to lie flat on the adhesively coated sheets, such as an asphaltum adhesive sheet or the like, the employment of a lesser number of particles to cover a given area of the shingles is required.

Certain phases of the features of our invention dealing with other embodiments of the process and the apparatus are claimed in our application Serial No. 200,850, filed March 31, 1938.

We claim:

1. In the manufacture of granular coated sheet material comprising a backing and elongated abrasive granular material adhered thereto by an adhesive, the step of controlling the deposition of said granular coating material on said sheet whereby the major axes of substantially all of the particles of said granular material are uniformly arranged in substantial parallelism with respect to each other and to the surface of said backing sheet.

2. The process of coating which includes as steps thereof feeding a substantially continuous and extended length of carrier or backing and applying an adhesive layer to a surface thereof, and depositing on said adhesive layer pulverulent abrasive grit particles of elongated nature in respect of their major axes under the influence of an electrical field whose lines of force extend substantially parallel to the plane of said backing and substantially at right angles to the longitudinal axis thereof for causing said grit particles to assume positions with their major axes substantially parallel with the plane of said backing and perpendicular to an edge thereof and substantially normal to the effective working surface of the article to be made.

3. The process of coating which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a surface thereof, and depositing on said adhesive layer a pulverulent abrasive grit while passing said backing edgewise through a non-uniform electrical field whereby the particles are subjected to a variation in potential gradient as the backing moves through the field, said field tapering in intensity from one edge to its opposite edge.

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MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Filed March 6, 1933 3 Sheets-Sheet 1

Fig. 1.

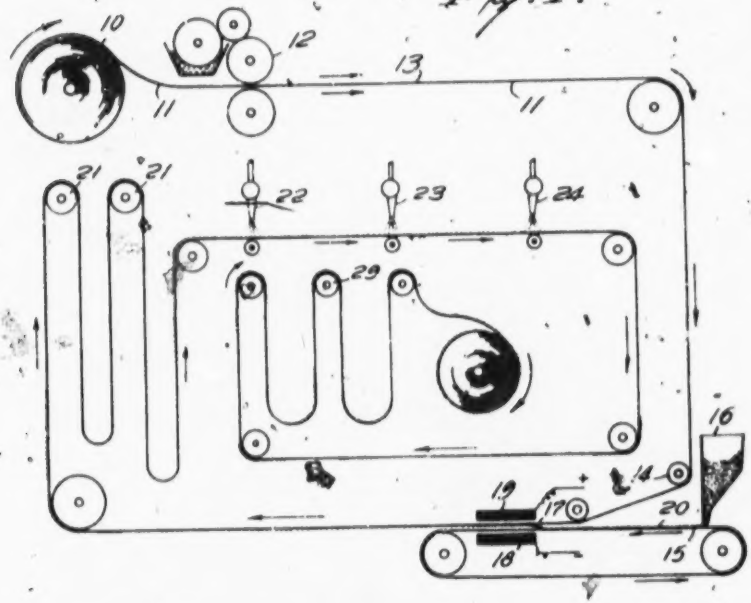

Fig. 2.

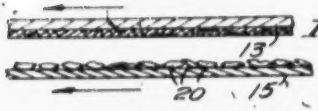

Fig. 3.

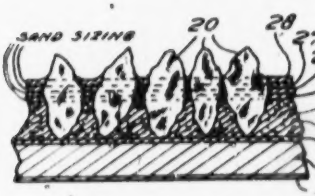

Fig. 4.

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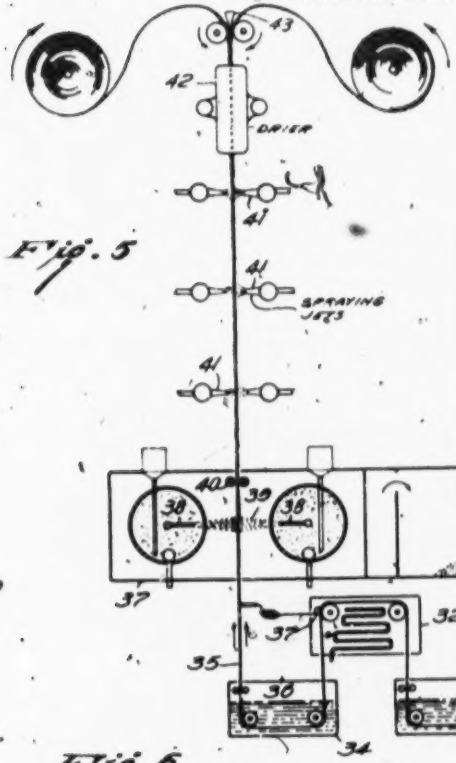
MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Filed March 6, 1933 3 Sheets-Sheet 2

Fig. 5



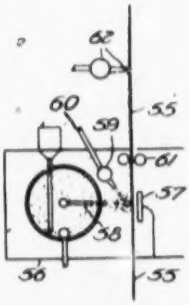


Fig. 7.

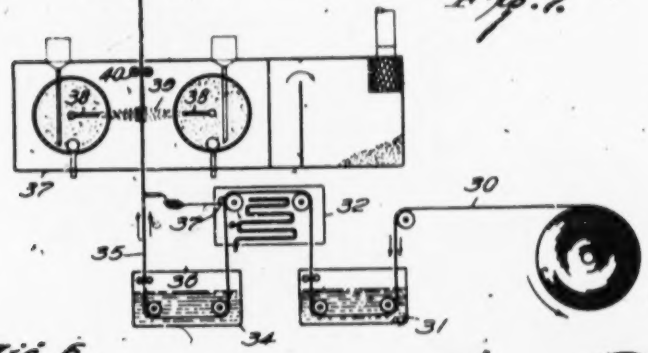
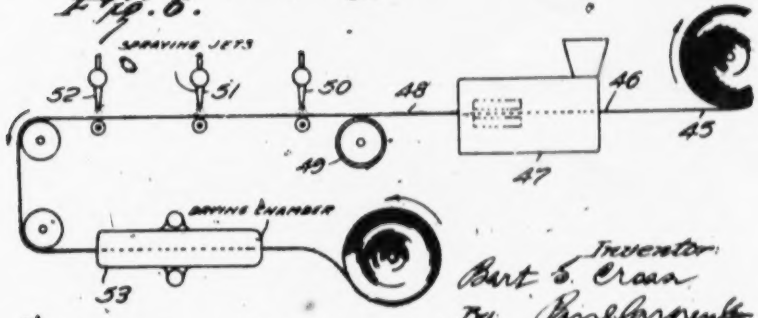


Fig. 6.



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MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

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Fig. 8

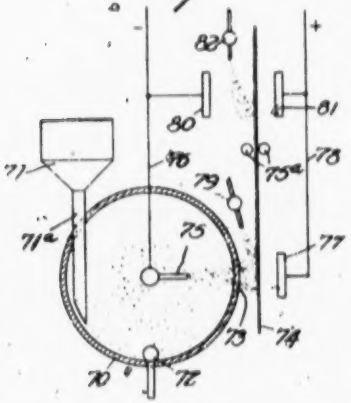
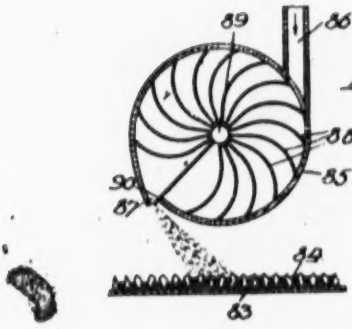


Fig. 9.



Inventor
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[fol. 766]

Patented May 5, 1942

2,281,558

UNITED STATES PATENT OFFICE

2,281,558

MANUFACTURE OF ABRASIVE ARTICLES AND APPARATUS THEREFOR

Bert S. Cross, St. Paul, Minn., assignor to Minnesota Mining & Manufacturing Company, St. Paul, Minn., a corporation of Delaware

Application March 6, 1939, Serial No. 260,253

11 Claims. (Cl. 91—68)

This invention relates to the manufacture of abrasives, to abrasive articles, and more particularly to such articles in the nature of sandpaper and the like.

It has been proposed to prepare abrasive articles in the nature of sandpaper by positioning the abrasive particles so that the abrading edges of maximum abrading efficiency are exposed by acting upon a carrier including a grit or layer of abrasive particles, with the abrasive particles in a mobile state, with an electrical field which orients, positions or deposits the abrasive particles so that a more efficient abrading surface is provided resulting from an arrangement of the abrasive particles with their longest axes more or less perpendicular to the plane of the carrier or backing material, thus exposing the sharpest edges of the abrasive particles. Such process, and the abrasive made in accordance with this method, are generally described in the applications of Carlton, Serial No. 432,668, filed Jan. 20, 1930, and the patent to Smyser, 1,998,899, and may be effectively used for my purposes, though other methods for more evenly positioning the abrasive particles are also suitable for my purposes.

The method of making abrasive articles in accordance with the above mentioned applications and patent, in the preferred practice as known to me, involves providing a carrier, such as a web of paper, cloth or the like with a surface coating of an adhesive material, and while the adhesive is in the active condition, depositing a grit or layer of abrasive particles, and simultaneously with the deposition, or subsequent to the deposition, subjecting the carrier and grit so deposited to the action of an electrical field, which more desirably positions the abrasive particles, or orients the same, so that the sharpest edges will be exposed at the abrading surface, and generally the particles will be positioned with the longest axes of the particles arranged more or less perpendicularly to the plane of the paper or carrier. Following this operation, the backing material or carrier, together with the binding coat and grit are exposed to finishing operations which set the binder coat partially or completely. Thereupon, the abrasive surface is given a sand sizing coat to seal any crevices which may be formed in the setting of the binder coat or to supplement any binder which may be lost due to the absorption or shrinkage of the binder, and furthermore, to more securely anchor the abrasive particles to the backing material.

The sand sizing operation, under the present process, may be flowed over the abrasive surface in relatively thin solution of the size coating material, by a doctoring or transfer roll operation, and the excess material is then wiped off, or otherwise removed, by passing the web through relatively flexible squeeze rolls or other wiping devices. The abrasive sheet so prepared is then matured, depending upon the character of adhesive material and sizing coat that is used.

While the aforementioned process produces desirable results, certain disadvantages are experienced in the care that must be exercised, affecting the speed of production, and under certain conditions of operation, having a tendency to disturb or alter the predetermined desirable position of the abrasive particles. Furthermore, where the binder coat is preliminarily applied to the backing material, such as the web of paper, cloth or the like, the thickness of this layer is calculated to be sufficient to fully anchor the abrasive particles, to properly hold the abrasive particles which are influenced electrically or electrostatically carrying the binder and grit, before submitting the same to an electrical field. This latter mentioned phase of the process may have a tendency to decrease the clearance angles of the abrasive edges, as well as to retard the speed of the orienting process.

By the aforementioned process for depositing or positioning the abrasive grit or particles, utilizing the influence of an electrical field, resulting in more or less erectly positioning the abrasive particles upon the surface of the web, the influence of the electrical field does not become instantaneously effective and an electrical charge may persist for a short period of time after passing from the influence of the electrical field, after which condition it is desirable that the abrasive grit or particles remain somewhat mobile, until the entire influence of the electrical field becomes dissipated, to desirably position the abrasive particles in a more or less erect position. Under such conditions of operation in depositing and forming the grit or layer of abrasive particles, a mobile condition of the abrasive particles is desirable and the finishing operation involving the increase of the binder coat and the application of the sand sizing coat, or coats, if accomplished under the conditions of operation to maintain this mobile position of the abrasive particles and without a movement deterring or disturbing influence, facilitates the formation of a desirable abrasive article, as contemplated by me.

Furthermore, by prior methods of making sandpaper which involve flowing (or brushing)

or mechanically distributing one or more sand size coats upon gravitationally deposited grit or abrasive particles with the material necessary for forming the sand size coat in excess, no particular difficulty is encountered in wiping away or otherwise removing the excess material necessary for forming the sand size coat. However, when utilizing the hereinbefore processes for more erectly positioning the grit or abrasive particles by the influence of an electrical field, flowing of the sand size material in excess and then removing the excess material not only has a disturbing influence upon the position of the abrasive particles where the binder coat is unset, especially so where the binder coat has not been completely matured or set, but also the sand size coat or coats formed by this method increases the clogging tendency of the sandpaper with the erectly positioned particles by reason of the decreased clearance angle resulting from the deposition of the sand size coat material in excess and the difficulty in removal of this excess from the aforementioned positioned grit or abrasive particles.

It is contemplated by my present invention to materially increase the efficiency of sandpaper made in accordance with electrical deposition methods by combining therewith a method for applying a size coat or any number of size coats, which will be sufficient to finally anchor the abrasive particles in position, by applying the material forming the size coat or coats without disturbing the electrically or electro-statically deposited or oriented particles or submitting the particles to any stresses in applying the sizing coat, which may disturb the position of the abrasive particles upon the backing.

It is further contemplated by my invention to combine with existing methods for making an abrasive sheet which include preliminarily forming upon a backing material, including a binder and a grit or layer of abrasive particles, sizing coat or coats, a method for applying the sand sizing coat or coats which controls and limits the application of the sizing coat or coats and avoids the necessity for removing any excess by squeezing or wiping operations which may disturb the predetermined position of the abrasive particles.

It is a still further object of my invention to combine with methods heretofore used for forming an abrasive article in the nature of sandpaper, and the preliminary steps of anchoring a grit or layer of abrasive particles upon a web carrying a binding coat, a method for applying the requisite thickness of binder coat or sizing coat or coats by a spraying process which will permit the addition of the requisite thickness of binding coat or sizing coat or coats without excess, and without any tendency to disturb the predetermined position of the abrasive particles upon the backing material.

It is therefore, a still further object of my invention to provide a process which combines with the positioning of grit or abrasive particles upon a backing material or carrier operating under electrical influence, the application of a binder, sand size or plurality of sand size coats, while maintaining the mobile condition of the abrasive particles so that the effect of the electrical influence may be completely obtained and the sand size coat or coats be increased, without disturbing the particles or the influence of the electrical field upon the particles, until the requisite binder coat and auxiliary sand size coat or coats have been developed sufficiently, while in the finally matured article, results in an anchored abrasive material of proper abrasion resistance.

It is therefore still a further object of my invention to provide a method of depositing a size coat or coats upon an abrasive sheet including a binder coat having positioned thereon a grit or layer of abrasive particles more or less erectly positioned by the influence of an electrical field when the particles are in a mobile condition and building up the size coat or coats to the point sufficient to properly anchor the abrasive particles in the finally matured abrasive article, to resist the stresses in abrading operations and without excess which may objectionably increase the clogging tendency of the abrasive article, by atomizing or spraying the sand size coat or coats in extremely fine condition between the abrasive particles and upon the binder coat or underlying coats.

For the attainment of the aforementioned objects and such further objects as may appear herein or be hereinafter pointed out, and for a clearer understanding of the process herein involved, reference will be made to the accompanying drawings, forming a part hereof, in which—

Figure 1 is a diagrammatic illustration of one embodiment of my invention;

Figure 2 is an enlarged detail of a section of the web and belt before deposition of the abrasive particles;

Figure 3 is an enlarged detail of the same immediately after deposition;

Figure 4 is an enlarged detail in section, of a completed abrasive sheet as made in accordance with my process;

Figure 5 is a diagrammatic view of another embodiment of my invention;

Figure 6 is a diagrammatic view of a still further embodiment of my invention.

Figure 7 is a fragmentary diagrammatic view of a still further embodiment of my invention.

Figures 7 and 8 are fragmentary schematic views of alternative forms of a further embodiment of this invention, and Figure 9 is a sectional schematic view illustrating a still further alternative form of the invention.

Referring now to the drawings for purposes of illustrating one embodiment of my invention, 10 represents a roll of fabric material, such as paper, cloth or the like, which preferably has been given some sizing operation to waterproof the same. The web 11 then passes through applicating rolls 12, at which point a coating of binder material 13 is applied, of requisite thickness. Beyond this point, the web carrying the binder coat in a tacky condition is then reversely directed so that the adhesive surface 13 is downwardly disposed at 14, and passes above a traveling belt 15. This traveling belt is so formed as to receive a deposit or layer of abrasive particles from the hopper 16 containing the same. The traveling belt and web of paper are timed in synchronism and adjacent the point 17, when the web and traveling belt are in close proximity the web and belt pass between electrodes 18 and 19 respectively. These electrodes are connected to a suitable source of electrical energy of any desired voltage and thereby create an electrical field and cause the particles of grit 20 to be directed against the web 11, carrying the binder coat 13.

The exact form of the electro-deposition and the details of the apparatus therefor are not par-

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similarly herein claimed and no further detailed description will now be made, but it will be sufficient to point out that in my preferred method, a uniform distribution of the abrasive particles upon the backing is accomplished approaching more or less a single layer, though with the finer grits of 180 to 200 mesh, this method includes a deposition of multilayers.

Abrasive particles as supplied in the trade are of unequal dimensions, the sizes of which are unequal and have shrouding edges of different sharpness. The effect of the electrical field upon the abrasive particles as just described will serve to more desirably position the abrasive particles for abrading operations such as by having the sharpest edges exposed, or the longest axes of the particles arranged more or less perpendicular to the surface of the paper or web.

For purposes of convenience, this desirable positioning of the particles herein referred to as positioning the abrasive particles by an electrical field will be referred to as erectly positioned abrasive particles, and by this term I mean to include the effect produced in so arranging the particles that their most efficient shrouding edges or points are away from the surface of the paper, whether the action is electro-static, electro-magnetic, or caused by any other method of orienting the particles with their most efficient shrouding edges exposed in the final abrasive surface.

After depositing the grit or layer of abrasive particles by the electrical field, as described, the web of paper 11, carrying the adhesive surface 12 and the abrasive particles 20, are passed over festooning racks 21, to set the adhesive coating 12, and to assure that in the subsequent handling of the abrasive article thus far formed, the abrasive particles will hold their predetermined desirable position.

The web of paper, as it leaves the electrical deposition apparatus is guided over guide rolls to the festooning racks 21, as just described, so as to minimize any contact with the surface of the web carrying the abrasive. At such points where the surface of the web carries the abrasive, the guide rolls contact the web at the edge thereof.

The festooning racks as just described are particularly desirable in connection with a binder coat, using an adhesive material dissolved or dispersed in a volatile vehicle, such as, for example, a mixture of resin and drying oils, in a volatile solvent, such as a petroleum distillate, of which steam spirits, naphtha are examples. The setting action may be accomplished by other means, depending upon the nature of the adhesive material, which will, for purposes of more fully illustrating applicant's invention, be hereinafter referred to and exemplified.

With an oil resin and solvent coating 12 and abrasive particles 20 as heretofore applied, the festooning operation may be continued for a period of about twenty-five minutes, or a period of time wherein the major proportion of the volatile solvent will be removed and the resinous become materially thickened, approaching a solid state. The nature of a binder of this character may be one made in accordance with the patent application of Otis, Serial No. 336,622, filed February 6, 1929, and may further include sufficient heating or baking treatment to ensure sufficient setting of the adhesive material.

The web as thus far prepared or, if desired, before partial drying by the festooning racks, is then brought in proximity to spray jets 22, at which point a fine atomized spray of sizing material is deposited upon the web of paper carrying the abrasive particles. The plane of the paper at this point, in relation to the spray jets is such as to ensure the spray striking the web of paper substantially at right angles for the major area sprayed by the spray. The force of the spray is such as to give very little lateral action, or have any tendency to disturb the position of the abrasive particles, and to further ensure an even and uniform distribution of the sizing material between the particles of grit.

It will be understood that the spray jets shown at 22, 23 and 24 may be connected to a single source of supply of coating material or may be connected to different sources so as to deliver subject to suitable control sizing coating materials of different degrees of hardness or flexibility when dried in order to produce, if desired, an article having consolidated adhesive coatings of different degrees of hardness and/or other characteristics when set.

The spray jets may be arranged as shown at 22 and 24, so as to increase the binding material between the grits to the requisite depth for properly anchoring the abrasive particles upon the web, with sufficient strength to resist displacement in abrading operations. The web may be passed beneath the spray jets to give any number of sizing coats, as more clearly illustrated in the enlarged detail shown in Figure 4, wherein 25, 26 and 27, and 28, show successively a plurality of sizing coats. The sizing coat or coats are applied to sufficiently anchor the abrasive particles upon the backing, to resist the stresses encountered in abrading operations, when the web is finally matured, but without excess, which may impair the clearance angles and shrouding efficiency of the abrasive particles. This is accomplished by using an extremely finely atomized spray and the sizing material solidifying more or less in an extremely thin coat. This coating may be increased in number to require no removal of excess material. The web then passes to festooning racks or dryers 29 for maturing the web as prepared.

In another embodiment of my invention, as more particularly illustrated diagrammatically in Figure 5, the duplex web 30 of paper, cloth or the like, is fed into a vat 31, which contains a coating composition in which there is dispersed electrical conducting material. This may be finely suspended graphite, a bronzing powder, a water solution of some electrolyte, such as salt, or similar material. The web is then conducted into a drying chamber 32, to set the preliminary coating and to take off any extraneous fluid. Adjacent the outlet of the drying chamber, the web makes contact with an electrode 33. From the drying chamber, the web is passed into a second vat 34, where the fabric is given a coating of adhesive material 35. The gauge adhesive material is controlled by the squeeze rolls 36, which also adjust the thickness of the binder upon the web of material. The web then passes to the grit deposition chamber 37 of the character more particularly described in the patent to Simpson, No. 1,702,680.

In this embodiment of the invention, as the web with the adhesive still moist and tacky, passes between the electrodes 38, the electrostatic discharge bombards the binder coating with electrically charged particles of abrasive material 39. This operation serves to position

the particles of abrasive material upon the binder carried upon the surface of the web so that the most efficient abrading edges of the abrasive particles are exposed, and in general, the particles are oriented with their largest axes substantially perpendicular to the plane parallel to the surface of the paper. The speed of the movement of the web in relation to the points between the electrodes 38 determines, with a given size of abrasive particles, the character of coating. Though the coating may be one to provide plural layers of abrasive particles on the web of fabric, it is preferred by me to adjust the thickness of the adhesive layer, the speed of movement of the web in relation to the electrodes and the character of the particles of abrasive material so that substantially a single layer of abrasive particles is coated upon the web, to produce an article in the nature of sandpaper.

With a web thus prepared, and while the adhesive is still moist, the web is passed through edge guiding rolls 60. While the adhesive may be suitably set, in accordance with the prior embodiment, I may directly pass the web through a series of jets 61 arranged to spray the full width of the web of paper, at which point a finely atomized spray of sizing material is directed against the web coated with the abrasive surface. While the spray coat of sand size may be accomplished by a single spraying operation, it is preferred by me to apply successive coats of sizing material, to gradually increase the binding material between the particles of grit, until the size coatings are built up to properly anchor the abrasive grit or particles to the backing material, yet without excess which may interfere with the proper clearance angles and abrading efficiency of the abrasive particles. The web then passes through a drying chamber 62, to partially set the web thus prepared.

After the web passes through the drying chamber, it is conducted adjacent to a knife 63, wherein the web of paper is separated. The two branches of the web thus split are separately formed into rolls or they may be conducted to other apparatus for finishing the same, such as for applying a back size before the entire web is passed through a maturing process, depending upon the character of adhesive that has been used.

In the process as described, the web of fabric is made with an abrasive layer 39 on opposite sides of the web and this may, under one phase of my invention, be practiced in order that an equalized discharge be obtained. However, it will be readily understood that in the coating process for applying the adhesive, only one side of the web may be coated with the adhesive material, to thereby produce a single web of abrasive fabric.

In the formation of an abrasive in the nature of sandpaper, as aforementioned, the binder coat 38, formed over a paper size coat or directly upon the backing, may be of a glue or protein base material, suitably waterproofed, if desired, by an insolubilizing or tanning operation, such as formaldehyde, tannin, potassium chromate, or it may be of a waterproofing material of oily or resinous constitution or combinations thereof, made and applied by way of example, in accordance with United States patents to Okie Reissue 17,593, Okie Reissue 17,594, Carlton 1,736,934 and Carlton 1,775,631 and others assigned to the Minnesota Mining and Manufacturing Company. The character of the binding coat, in one phase of my invention, determines the character of treatment to be given to this coat immediately following the deposition of the grit or abrasive particles, and preceding the application of the sand sizing coat or coats.

In order to more expeditiously practice the finishing of the sandpaper in accordance with my process, for purposes which will appear hereinafter, the binder coat that is applied before depositing the grit or abrasive particles, is of a thickness which will be just sufficient to hold the abrasive particles against gravitational displacement. This procedure not only reduces the time element in positioning the grit or abrasive particles by an electrical field, and permits the electrical field to more effectively orient the abrasive particles in the desirable position aforementioned upon the backing, but also provides a film which may be very rapidly set, to hold the grit or abrasive particles in the desirable position during the time that they are submitted to the spray coat of sand size. And I consider, as one phase of my invention, to deposit grit or abrasive particles upon a backing material carrying a binder coat of a minimum thickness to hold the grit or abrasive particles against gravitational displacement, followed by spraying of the sand sizing coat or coats, as this thin film of binder coat will respond more rapidly to the maturing treatment, and therefore more readily, firmly hold the abrasive grit in the desirable position resulting from deposition by an electrical field, and therefore permitting a more rapid application of the spray coats by a heavier and more powerful blast of spray, necessary for applying the sand sizing coat or coats.

In the embodiment illustrated in Figure 5, using a finely atomized, rapidly drying spray for applying the size coat, this size coat may be applied before the binder coat has set to any appreciable extent and, by proper adjustment of the spray, immediately following the electrodeposition of the grit or abrasive particles.

In the aforementioned methods and by the installation as described, reference has been made to partially or completely setting the binder coat before spray coating the sand size and that the character of the setting treatment would be dependent upon the character of the binder used. Thus, the binder coat may be a normally solid material which is sprayed in a volatile solvent, and setting or partial setting may be effected by partial vaporization of the volatile solvent. Furthermore, the spray coats issuing from the nozzles 61 may have different characteristics as to degrees of hardness or flexibility when finally set as hereinabove pointed out.

In another embodiment of my invention, as more specifically illustrated in Figure 6, a web of backing material, such as paper, cloth or the like, preferably after first sizing the same, is given a binder coating 66, of heat responsive material, using substantially no volatile vehicle. Such material may be a properly heated shellac or resin, artificial resin, waxes or gums, which generally may be maintained fluid by heating, but which, upon cooling, rapidly solidify. Under these conditions, the web carrying the binder coat 66 is passed into a chamber 67, which is kept at temperatures sufficient to maintain the binder layer 66 in a fluid or semi-fluid condition.

Under other conditions of operation, the heat responsive material may be one which sets, hardens or rigidifies on heating. Such materials, I may exemplify as albuminous adhesives of the character of egg albumen or blood albumen, and

[fol. 770]

other similar congriable materials, such as, for example, latex, viscose containing a weak acid solution admixed therewith in noncoagulating proportions at ordinary temperatures. Under third conditions, using the heat congriable material or materials solidifying under increased temperatures, the chamber 67 is maintained at atmospheric temperatures.

Within the chamber 67, the web with the adhesive coating 66 in its tacky consistency, is given a deposit of grit or abrasive particles 68 and is submitted to the process for evenly positioning these abrasive particles in accordance with any of the methods aforementioned and more specifically described, for purposes of example, in the application of Carlton, Serial No. 432,060, and the patent to Simpson, No. 1,789,896. The web then passes over a roller 69, to rapidly set the binder coating. The roller 69 has provisions for being either chilled or heated. The chilling fluid is used where the binder coat 66 is of a nature which responds to a reduced temperature to rapidly set and solidify, and where materials, such as those hereinabove referred to, responding to reduced temperatures to rapidly set or solidify, are used. Where the binder material used is one which is heat congriable, the roller 69 is connected with suitable heating means such as steam, to maintain the roller at a temperature sufficient to rigidify, congriate or otherwise set the binder coating.

It will be understood that the time element of contact between the web as it contacts with the roller 69 may be such as to effect the purposes hereinbefore referred to, of rapidly setting, solidifying or stiffening the binder coating.

It is further understood that the nature of the binder as originally applied for my purposes, prior to the entry into the chamber 67, is one that is sufficient for fastening a binder coat for holding grit as made by a pure gravitational deposition method, but is insufficient, in the finally matured article, to hold evenly positioned abrasive particles, and for purposes of more rapidly passing from the grit deposition step to the sizing steps which will hereinafter be described, the binder coat is preferably applied of a thickness which will be the minimum necessary to hold the particles against any gravitational tendency to displace the same from the erect position previously referred to. This minimum sizing up to the quantity found proper for an ordinary gravitationally deposited grit, is of value for purposes previously described and also shortens the time necessary for setting the binder coat, so that the web may be immediately subjected to the spraying process.

In the embodiment illustrated in Figure 6, the web, treated in accordance with the process just described, is subjected to a spray of sand sizing material by the jets 80, 81 and 82. These jets emit a fine, atomized spray of sand sizing material. The sizing material may be an ordinary glue-base material, where glue bond sandpaper is to be made, or it may be in the nature of a waterproofing material. Preferably, and by way of example, the flexible waterproofing materials made in accordance with the patents to Carlton and Otis, aforementioned, may be used so that a resinous, oil-resin, cellulose compound, such as nitro-cellulose, preferably modified by a polyhydric resinous material, cellulose acetate, may be used as the base. Those resinous materials which may be rendered liquid by heat are so used. In general, however, I prefer to use the materials in a volatile solvent or vehicle. Additionally, also, aqueous dispersions of rubber, such as latex and similar materials, halogenated rubber and isomers of rubber, such as described in the applications of Hatch, Serial No. 218,309 filed Nov. 18, 1938 and Hatch and Netherly, 418,148 filed Jan. 2, 1930, may be used.

The ingredients that are used for sizing the paper, formation of the binder coat and the sizing coat or coats, need not be of the same materials and flexibility and may be varied by use of a gradiently harder binder and sand size materials. In general, sizing materials which are compatible with each other are used.

Where a rubber sized paper is used, a resinous material or resin bond, oil and resin sand size are compatible. For an oil-resin binder coat, nitro-cellulose, preferably modified by a polyhydric resin in a common solvent, is compatible.

In using any of the sizing materials, suitable adjustment is made of the temperature of the sizing material or the solvent used, so that an exceedingly fine spray may be deposited, and additionally, adjacent the point where the spray strikes the web of material, temperature conditions may be maintained so that the atomized particles strike the web in a more or less solidified or thickened condition, so that the binder or sizing coat or coats are almost in a fairly concentrated condition. Thus, with a hot liquid resinous material for the sand size, the web may be maintained approximately at a temperature at which the resinous material will begin to solidify, thicken, or concentrate to a substantial extent. For a sizing material including a volatile vehicle, temperatures adjacent the spraying zone may be raised to increase the volatilization of the vehicle.

In the application of the sizing coat or any number of successive coats by the jets 80, 81 and 82, no excess material will be applied and the spray coats may be controlled below that thickness at which the size coat would ordinarily interfere with the abrading edges of the abrasive particles, and serve to increase the clogging tendency of the abrasive article, when used in abrading operations.

To exemplify the conditions of operations where successive sprays of binder coats and sizing coats may be applied to leave the grains of abrasive particles well supported, reference will now be made to various conditions of operation. Where I have indicated sprays 22, 23, 24, 41, 42 and 82, these sprays may be the spraying nozzle of a spray gun of a character known on the market as the No. 15 Apex Spray Gun, adapted to project a fan shaped spray about six inches wide and about one-half inch thick. With such type of apparatus, it is preferred by me to hold the nozzle about eight inches from the web to be treated and direct the same at an angle of approximately 90° to the work.

For purposes of projecting a glue binder upon a web, air pressure between 60-70 pounds is used, and discharged at about room temperatures of 65-80° F. The glue solution was preferably maintained at about a temperature of 150 to 180° F., though temperatures of 95-120° F. are operable. The concentration of the glue, using a hide glue, should preferably be below 10%, where hide glue of 165 millipoise is used. With lower grades of glue, however, of from 60 to 100 millipoise, concentrations as high as 15% may be used.

The conditions above given for glue, with the variables that may be encountered, are prefer-

ably maintained to work in the direction of the flood coat and a tendency for the sprayed particles to thicken upon deposition, yet below the limit where there is any tendency to form any caps upon the cutting edge of the grains, and the force of the spray, especially under the conditions above described, in addition to the force of the spray, tends to consolidate and unite the particles of spray into a unitary mass. Variables which cause such rapid solidification of the spray particles to an extent that the formation of round caps appears, is avoided.

While I have indicated that with compressed air and temperature conditions above indicated concentrations of glue as high as 10% may be used for the high grade glues and concentrations as high as 15% with low grade glues, still higher concentrations may be used. Under these conditions, however, steam at about 50–70 pounds pressure may be substituted for the compressed air, and utilize a glue concentrate of about 21%. This may be used without any evidence of glue caps on the abrasive particles.

It will be understood that the rate of evaporation, viscosity or concentration of the fluid, surrounding temperatures, humidity, distance of the spray from the work and the material used, are all variable factors which are varied from the conditions aforesaid and will require suitable adjustment, and the desirable condition of operation may be ascertained in a general way, maintaining the condition of the spray preferably between limits showing a definite concentration of the material sprayed and below the point where variations may cause the formation of caps.

For using a waterproof material and an organic solvent, clear lacquer of a base may be used. This is preferably thinned with an equal quantity of a thinner for the lacquer and a spray gun is operated at air pressures of from 45–60 pounds, though pressures as high as 75 pounds may be used. Again, the variables, such as the surrounding conditions, as above emphasized, may require adjustment of the spray to project a coating of more concentrated or thickened condition, the formation of caps upon the abrasive particles at their points being the limiting conditions in the direction of operating the spray for forming a more viscous or concentrated deposit.

With a glue base material of the character described, and operating conditions as described, approximately four coats may be given. With the waterproof type of lacquer, as many as ten coats may be given. It will be understood that the grit size and the character of grit and the other variable conditions indicated may also qualify the number and nature of the spray coats that may be applied.

By applying the size coat or coats in accordance with the method described, by a finely atomized spray of the size coat material and under the conditions which will cause the residuum carried in the spray to quickly solidify, a web of material carrying erectly positioned abrasive particles may be provided with the anchoring coat or coats, without an excess, which would ordinarily tend to increase the clogging tendency of the finally formed abrasive article.

After leaving the points at which the spray coats are applied, the web may then be passed over festooning rolls, or other means for partially or completely maturing the abrasive article, such as by passing the same through a drying chamber 53, from which point it may be formed into rolls for more convenient handling, for subsequent complete maturing, or if sufficiently matured in the drying chamber, to be held for subsequent severance in the form in which the abrasive article will find its way on the market.

Though I have described in the embodiments illustrated, the application of a binder coat followed by the application of sand sizing coats for an embedded grit or abrasive particles which have been erectly positioned the method may include substantially simultaneous deposition of the binder coat and deposition of the grit by the influence of an electrical field and the apparatus diagrammatically illustrated in Figure 5 is admirably suitable for this purpose, as I may, adjacent the electrodes 56, include spray jet or jets for simultaneously applying a binder material while the sheet is bombarded with abrasive particles. An extremely finely atomized spray material using either no solvent at all or a non-inflammable solvent is preferably used; in this form of operation, the binder coating operation may be entirely omitted or reduced to the minimum.

For purposes of illustrating the method briefly aforementioned, reference will be made to Figure 1. In this construction, a backing material 58 is conducted into a chamber 56, of substantially the same character as that illustrated in connection with Figure 5. In this embodiment, the backing material need not be coated with an electrical conducting material, but is preferably surface sized, with a suitable sizing material compatible with the binding material hereinafter used. The right hand electrode 36, illustrated in connection with Figure 5, may be omitted, and in its place there is substituted a grounded electrode 57, disposed at a point opposite to the grit dispersing electrode 56, of the same general construction as described in the previous embodiment shown in Figure 5. Adjacent the point between the electrodes 57 and 56, there is positioned a spraying nozzle 59, preferably to lead off from a line 60 connected so as to be operable with such spray nozzles of the character noted at 51 in the embodiment shown in Figure 5, or formed as part of a series of chambers, such as shown in Figure 3.

The operation for electrostatically bombarding the web of paper in accordance with the embodiment illustrated in Figure 7 is accompanied by simultaneously spraying the particles and the web of backing material 58. The highly dispersed particles formed by the mist or spray of atomized particles of binding material do not interfere with the desirable position of the abrasive particles. The binding material as applied by means of the spray is preferably so adjusted that upon striking the backing material, the coalesced particles will reach a more or less thick liquid or semi-solid state, to effectively hold the particles of abrasive material in the predetermined, desired erect position.

After passing the point between the electrodes 57 and 56 and the spray nozzle 59, the web is conducted between guide rollers 61. These are preferably edge rollers which do not interfere with the surface coating of binder material and abrasive particles, though for purposes of compacting the surface, where a built-up layer is desired, the rollers 61 may be extended for the full width of the web.

It will further be observed that care is exercised to carefully insulate the rollers 61 so that discharge occurs between the electrodes 57 and 56, and not from the paper through the rollers 61.

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After passing from the chamber, the web 86 and its coating of abrasive particles may be given one or more sizing coats by the spraying nozzle 93. One or more of such nozzles may be used to build up the sand sizing coat, or the web may pass progressively through a series of chambers, such as 86, to progressively build up any number of layers of abrasive particles, so that the web may have any desired thickness of abrasive particles, or the abrasive particles may be built up to any desired thickness upon the carrier, by moving the carrier at a relatively slow rate between the electrodes 87 and 88, and the spray nozzle 93, associated therewith.

In the embodiment illustrated in connection with Figure 7, novelty is attributed not only to spraying of erectly positioned particles upon a backing material, but the simultaneous deposition of the abrasive particles and the atomized binding material. The novelty of this embodiment of the invention I attribute not only to simultaneous application of the binder coat and the grit to more facilely permit of an erect positioning of the abrasive particles, but to an ability to continuously and progressively build up the layer of abrasive particles without waiting for the binder coat to set or dry, permitting either an additional coating or coatings of sand sizing material, or other abrasive particles and binding material to be applied.

Referring now more particularly to Figure 8, there is provided a container or chamber 70 conveniently cylindrical in contour similarly to the chamber shown in Figure 7. Comminuted abrasive material is supplied to the chamber 70 from a hopper 71 through a tube 71a.

An air blast may be introduced into the chamber 70 at 72 for creating a cloud of abrasive material therein.

At one portion of the container or chamber 70 I provide an outlet 73 and past this outlet 73 there is fed the fabric backing 74.

Within the chamber 70 I provide an electrode 76 which is connected by conductor 76 to one side of a suitable source of high voltage and in substantial alignment axially with the electrode 76 I provide an electrode 77 back of the fabric 74 and connected by suitable conductor 78 to the opposite side of the source of high voltage.

It will be observed that the source of relatively high potential through the medium of the electrodes 76 and 77 establishes an electrostatic field of desirable strength between these two electrodes. It will be understood that to simplify the diagram the conductors 76 and 78 have been shown in parallel relationship, but it will be understood, of course, that these electrodes will be kept at a sufficient distance apart so that disruptive discharges cannot occur or other leakage of current which would tend to decrease the electrostatic field sought to be established between the electrodes 76 and 77.

A spray nozzle 79 is provided arranged similarly to the nozzle 93 shown at Figure 7 and adapted to direct an atomized adhesive into the zone of the electrostatic field so that in addition to the mechanical deposition of the adhesive an electrical deposition of adhesive takes place. This prevents undue deposition of adhesive on surrounding parts of the apparatus and ensures that the major portion of the adhesive as desired reaches the sheet or backing 74 preferably simultaneously with the deposition of the abrasive thereon.

The fabric with the coating of adhesive and abrasive thereon then passes from the zone of the electrostatic field established between the electrodes 76 and 77 between edge guiding rollers 79a and thence passes between supplemental electrodes 80 and 81. At the electrostatic field thus established between the electrodes 80 and 81 I provide an auxiliary nozzle 82 adapted to spray into the electrostatic field, but not toward the fabric 74, an atomized stream of adhesive material which may be deposited by the action of the electrostatic field as a sizing coat upon the abrasively coated fabric 74.

In view of the fact that the spray produced from the nozzles 79 and 82 is finely comminuted and of relatively low concentration as to conductive adhesive, it will be understood that the spray produced at this point both with respect to Figures 7 and 8 does not tend to materially reduce the strength of the electrostatic field, even where moisture containing adhesives, such as glue, are employed instead of non-conductive waterproof adhesives.

It will be understood that by disposing the auxiliary nozzle 82 at the angle shown, an improved dispersion of the finely divided adhesive particles is produced resulting in a more uniform distribution of the adhesive upon the web.

Referring now to Figure 9, here an alternative form of commuting means is disclosed for the treatment of the adhesive and for depositing the same on the web 83 containing the abrasive particles 84.

In this form of the invention there is provided a drum 85 having an inlet 86 for delivering a fluid adhesive to the interior of the drum. The drum is provided with outlet 87 whose axis of discharge is directed toward the grit coated sheet 83.

A brush having relatively stiff bristles indicated at 88 is arranged within the drum 85 so that as the brush is rotated in the direction indicated by the arrow the bristles will take up adhesive from the inlet 86 and as the bristles strike the edge 89 of the drum adjacent to the outlet 87 the adhesive in liquid form will be thrown as a fine spray on to the adhesively coated sheet.

It will be understood that this form of the invention may be adapted for use with any of the previous forms hereinabove described and, of course, in some circumstances, it will be necessary to mount the brush below the web, in which event appropriate modification may be made for supplying the adhesive under pressure sufficient to cause it to flow through the inlet 86 to a point adjacent to the bristles of the brush.

Thus, by the centrifugal force of the brush revolving the adhesive particles picked up by the bristles of the brush will be caused to be projected forcibly in a cloud form toward and on to the surface to be coated.

Not only does the spraying operation as above described penetrate between the particles of abrasive material, by reason of the use of the spray, but where an inert atmosphere is used, these particles also become electro-statically charged and more effectively impinge upon the web of backing material, and therefore more securely and effectively unite the abrasive particles.

In some cases it is desirable to employ a binder and sizing coats, materials which do not deform materially when set, and, therefore, do not, either by capillary action or in course of hardening to a flexible state, cause a displace-

ment of the grit particles from the desired oriented positions. For this purpose I have found to be suitable the phenolic resins and other synthetic or artificial resins, such as urea resins, oil resin mixtures wherein the metering steps are conducted so as to prevent the displacement of the electrically oriented particles by controlling the viscosity during the interval of setting.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent, is:

1. The method of forming abrasive coatings upon a carrier, the steps which include simultaneously dispersing the abrasive particles upon the carrier and applying an adhesive material in a volatile vehicle in the form of a spray impinging upon the abrasive particles in transit to the carrier, while maintaining the spray of adhesive material under conditions tending to solidify and concentrate the same but below that at which a tendency to form caps of the adhesive material upon the abrasive edges of the abrasive particles is observed.

2. The process of applying coatings which includes the steps of dispensing and depositing a plurality of solid particles on a surface by the action of an electrical field, and depositing thereon in dispersed condition an adhesive material for binding said particles by the action of an electrical field.

3. In a coating apparatus, means for electrically projecting and dispersing a plurality of abrasive particles to form an abrading surface, and means in proximity converging with said first projecting means for mechanically and electrically applying and dispersing an adhesive material for retaining the particles in predetermined position on said surface.

4. In a coating apparatus, means for supplying abrasive and adhesive materials, and means for electrically projecting and dispersing simultaneously said abrasive and adhesive materials to form an abrading surface.

5. In a coating apparatus, means for supplying abrasive and adhesive materials, and means for electrically projecting and dispersing simultaneously said abrasive and adhesive materials to form an abrading surface, and means for supplementally electrically depositing and dispersing an adhesive material on said surface.

6. The process of producing an abrasive article which includes as steps thereof depositing and dispersing abrasive particles on a carrier by the action of an electrical field to cause the abrasive particles to assume oriented positions on said carrier with their major axes substantially perpendicular to the plane of the carrier, and simultaneously while intermingling with the dispersed particles of abrasive materials in transit to the carrier spraying an adhesive material upon the carrier to converge with the deposition of the particles in transit to the carrier, under conditions which cause a relatively rapid setting thereof for retaining said abrasive particles in their oriented positions on said carrier.

7. The method of making abrasive coated products which comprises as steps thereof directing a mixture of abrasive grains and a solvent free, thermoplastic binder in finely comminuted form upon a backing maintained with an adhesive coating, to impinge the abrasive particles upon said adhesive coating and to cause said mixture to adhere to the backing, while said coating is adhesive and, under conditions of plasticity of the adhesive and binder to cause the binder to adhere both to the grains, and the adhesive carried by the backing.

8. The method of making coated abrasive products which comprises applying to a backing a base coating of liquid adhesive, adding a thin layer of abrading grains to the adhesive coated surface while said coating is in an adhesive condition and applying a sizing coating of substantially solvent free thermoplastic resinous adhesive material in comminuted form to adhere the same by impingement thereon, whereby the time necessary for setting the coated abrasive product by the thermal changes is reduced, and a substantial proportion of the abrasive grains thereon remain with exposed edges.

9. The method of making abrasive coated products which comprises attaching a thin layer of abrasive grains to a backing by a base coating of liquid adhesive, applying a sizing coating of a substantially solvent free thermoplastic resinous adhesive material in finely comminuted particle form, to supply a full quantum of binder for anchoring the grains and by the impinging movement thereof to cause said particles to become attached to the abrasive grains and to become united with the base coating of liquid adhesive.

10. The method of fabricating coated web material which comprises applying a base coating of liquid adhesive to a surface of the web, applying a layer of abrasive particles to the adhesively coated surface, moving the abrasive-coated web into an electrostatic field, moving sizing material of solvent free material in finely comminuted form into said electrostatic field, electrically dispersing and projecting said finely comminuted sizing material onto the abrasive coated web prior to curing said base coating of liquid adhesive and thereafter curing both the previously applied liquid adhesive coating and finely comminuted sizing coat in one operation.

11. The method of manufacturing abrasive coated sheet material which comprises coating a surface of sheet material with a liquid adhesive, applying a layer of abrasive granules to the adhesively coated surface, projecting a layer of sizing material of solvent free material in finely divided form onto the abrasive coated sheet prior to setting the said liquid adhesive so that the sizing material becomes adhered to the liquid adhesive coating and thereafter curing both the layer of liquid adhesive and finely divided sizing material in one operation.

KENT S. CROSS.

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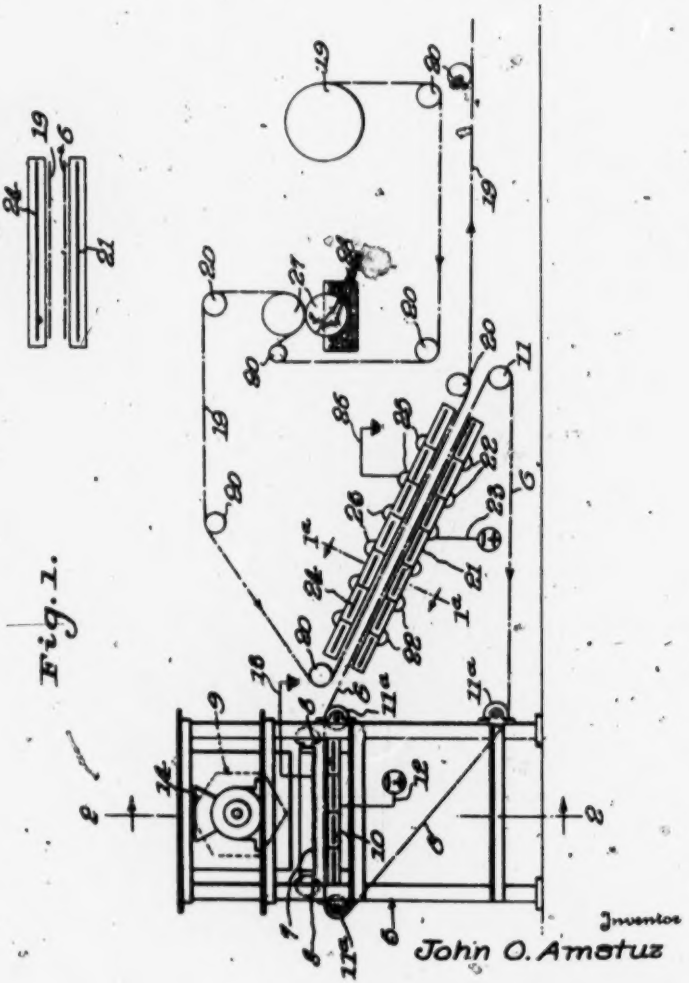
APPARATUS FOR COATING

Filed Aug. 19, 1939 5 Sheets-Sheet 1

Fig. 1a.

Fig. 1.



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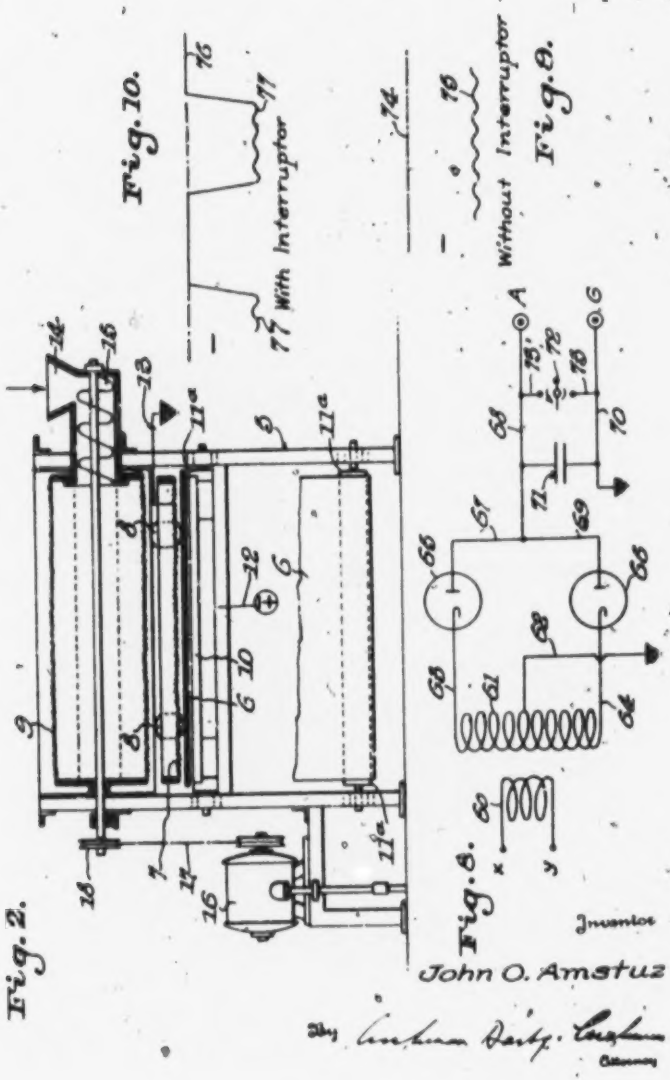
APPARATUS FOR COATING

Filed Aug. 19, 1939 5 Sheets-Sheet 2



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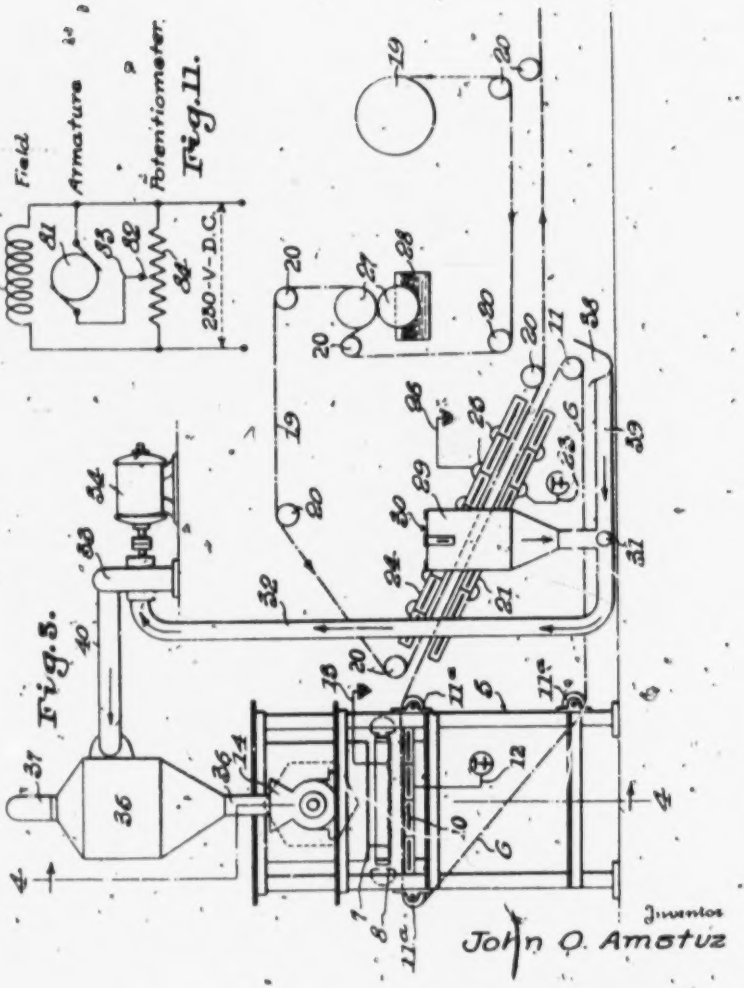
APPARATUS FOR COATING

Filed Aug. 19, 1939 5 Sheets-Sheet 3

Fig. 11.

Fig. 5.



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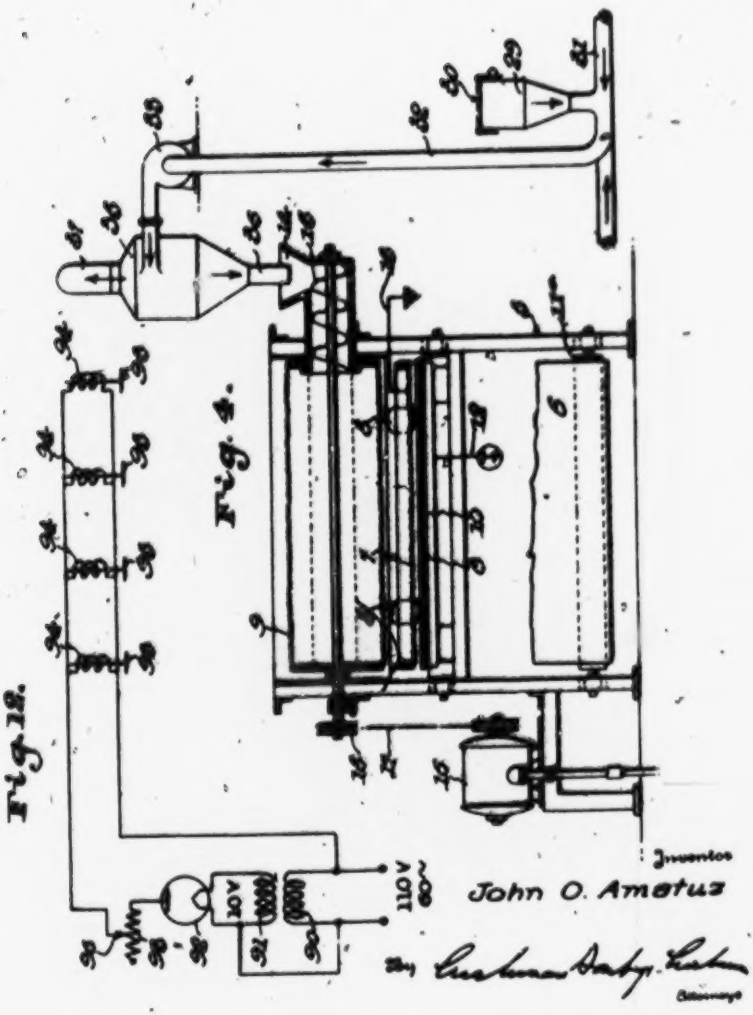
Filed Aug. 19, 1939 5 Sheets-Sheet 4



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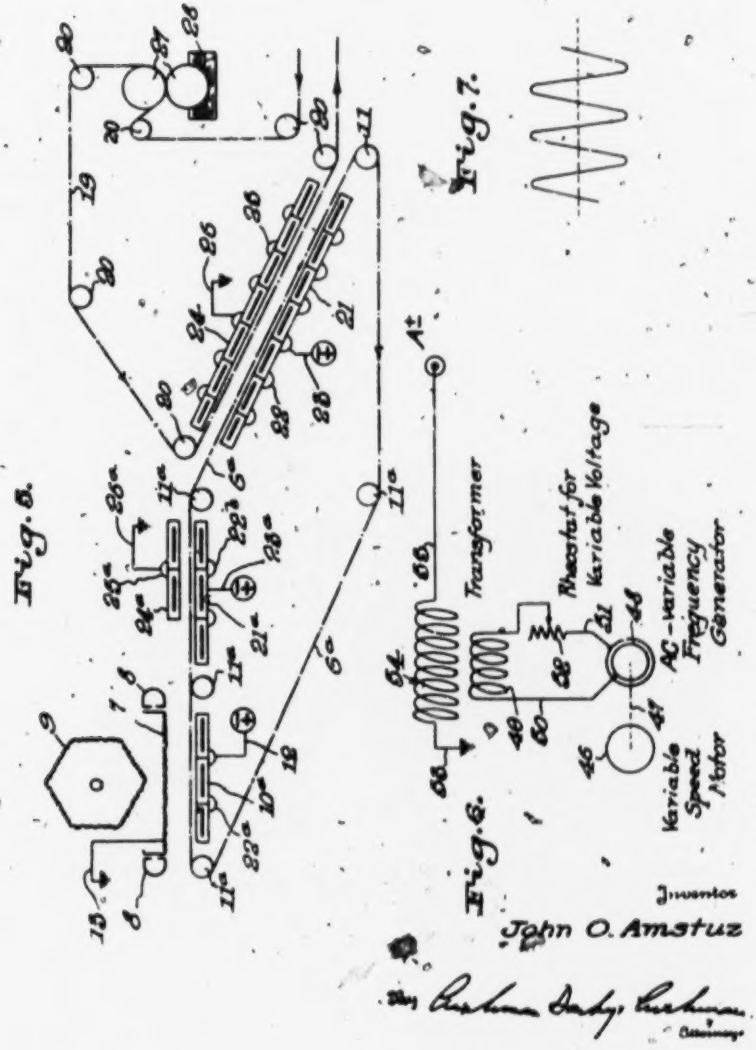
APPARATUS FOR COATING

Filed Aug. 19, 1939 5 Sheets-Sheet 5



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Patented Aug. 22, 1944 2,356,489

UNITED STATES PATENT OFFICE

2,356,489

APPARATUS FOR COATING

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Application August 19, 1939, Serial No. 291,886

12 Claims. (Cl. 91—8)

The invention of the present application is an apparatus for coating, and more particularly for coating with fibrous material, such as flock, for the production of piled surfaces and pile-surfaced materials.

Heretofore, it has been proposed to produce pile-surfaced materials by depositing pile-forming particles, such as fibers or flock, upon an adhesively surfaced foundation material, and to orient or arrange the particles, preferably in parallelism and in endwise arrangement normal to the foundation material, by mechanical or electrical action. In some instances, both mechanical and electrical forces have been used. A process and apparatus involving electrical means alone is disclosed in my copending application Serial No. 108,706, filed November 2, 1936, and a process and apparatus employing both electrical and mechanical means is disclosed in the application of Harry A. Wintermute, Serial No. 699,456, filed November 23, 1933. For an example of a purely mechanical method and apparatus, reference may be had to the patent to Krueger, No. 1,965,552, dated April 17, 1934.

It has also been proposed, as disclosed in the above mentioned patent, to loosen and separate the fibers to some extent before they are subjected to mechanical or electrical action, or to both, in order to facilitate their deposition and orientation upon the adhesively coated foundation material.

The present invention is based upon the discovery that superior results may be obtained if the fibers are electrically oriented and deposited upon a supporting surface before being subjected to the mechanical or electrical forces which serve finally to deposit them upon the adhesive surface. It is also based upon the discovery that this preliminary electrical orientation upon a supporting surface, such as a carrier sheet, facilitates the subsequent deposit and orientation upon the adhesive foundation by transfer thereto from the carrier sheet. I have discovered that if the preliminary orientation on a carrier sheet is accompanied by an electrical charging of the particles, they are rendered more responsive to the electrical field which deposits them when they are moved into the latter field by the carrier sheet.

An object of the invention is to provide an apparatus by means of which the flocks, for example, may be continuously subjected to an electrical charge and electrically oriented upon a supporting surface, preferably immediately prior to their entry into a field by means of which they are deposited and finally oriented on and secured to the adhesive surface.

While the invention is particularly useful in the art of coating, it is also applicable to the feeding of comminuted material generally, and in connection with either mechanical or electrical coating devices or a combination of the two. It is also useful in connection with the feeding and coating with abrasive grains and other comminuted material, such as, for example, comminuted cork in a conveying or coating system.

It is an object of this invention to provide a uniform feed of comminuted material. It is a further object of the invention to break up or separate comminuted materials, such as flocks, so that the same may be more readily coated. It is another object of this invention to eliminate knots or clusters of comminuted material so that the comminuted material may be coated as individual particles. It is a further object of this invention to continuously form a uniform layer of flock upon a feed belt used to convey flocks and other comminuted material through a coating device. It is another object of this invention to orient elongated particles, such as, for example, flocks, before they enter an electro-coating device, which propels them to an adhesively coated backing whereby the comminuted material is more readily oriented and coated by the coating device. It is still a further object of this invention to pre-charge comminuted materials, such as flocks and other poor conductors, and to deposit and orient the materials on a carrier sheet before they enter an electrostatic coating device. Further objects of the invention are to provide practical apparatus by which one or more of the objects mentioned may be readily accomplished. Other objects will be in part obvious or in part pointed out hereafter.

In carrying out the invention, there is provided in connection with apparatus such as is disclosed, for example, in my copending application above referred to, means for preliminarily subjecting the flocks to an electrical field which will charge and/or orient them preliminary to their entrance into the field which serves to deposit the flocks upon an adhesively coated foundation. In association with the field, there may be provided means for mechanically separating the flocks, such as, for example, a rotary screen or screen conveyor. In addition to mechanical means for separating the flocks, it often is advantageous to use the electrical means for separating the flocks that are provided, as for example, the vibrating screen, which constitutes one electrode of an elec-

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trostatic field, which is used to separate, disperse and uniformly deposit the fibres. Preferably, after a certain amount of mechanical distribution and separation, and in many cases, also after electrical separation and dispersion followed by deposition upon a supporting member, the flocks are caused to pass through an electrical field by means of which they are charged and also preferably oriented in relation to one another. For this purpose, a conveying belt or other carrier sheet may be used and the electrodes arranged in relation thereto in such a way that the particles are oriented on the belt substantially perpendicular to its surface. Immediately following this orientation and, preferably, before they lose their charge, the flocks, carried by the belt or sheet, are then subjected to the electrical field or other means, by which the particles are oriented, arranged, and deposited upon the adhesive coated foundation material. By this preliminary treatment, the flocks are handled more readily by the electrical field or other means which orients and deposits them upon the adhesive foundation, and a more uniform coating in the final article is more readily produced. The pre-charging of the flocks and the positive conveying of the same into a final electrical field, employed to produce the coating, enables that field to produce a more uniform product, since the fibers are pre-oriented and are also more responsive to the field which propels them with greater ease toward the backing material and attaches them to the adhesive foundation more evenly and with greater tenacity.

For breaking up and separating the flocks and other comminuted material and for dispersing the comminuted material and forming a uniform deposition of the same upon a feed belt or a similar conveying device, I may use either direct current or alternating current, but I prefer to use pulsating direct current or alternating current. I provide a means of varying and controlling the number of cycles and the voltage amplitude of both direct current and alternating current. Where alternating current is used, a preferred range of frequency is 2 to 200 cycles per second and for pulsating or interrupted direct current, a preferred range is 2 to 200 impulses per second. While not limited thereto, I prefer a voltage range of from 5000 to 75,000 volts with electrode spacings of one-half inch to three inches. I have obtained good results with many flocks with an electrode spacing of one and three-quarters inches using 60,000 volts and 60 cycle alternating current.

The apparatus by which my invention is carried out will be explained by reference to the accompanying drawings in which:

Figure 1 is a side elevation of one form of apparatus which may be used for carrying out my invention.

Figure 1a is a section on the line 1a—1a of Figure 1.

Figure 2 is a section through line 2—2 of Figure 1.

Figure 3 is a side elevation of another form of apparatus for carrying out my invention.

Figure 4 is a section through 4—4 of Figure 3.

Figure 5 is a side elevation of another form of apparatus for carrying out my invention and shows a special arrangement for pre-charging the flock before it enters the electrostatic coating device.

Figure 6 shows a wiring diagram for the alternating current used in carrying out my invention.

Figure 7 is a typical sine curve illustrating the variation of the potential on an electrode when the alternating current provided as illustrated in Figure 6 is superimposed upon the electrode.

Figure 8 shows a wiring diagram for the uninterrupted direct current and interrupted direct current used in carrying out my invention.

Figure 9 illustrates an uninterrupted direct negative potential.

Figure 10 illustrates an interrupted direct negative potential.

Figure 11 shows the electrical connections of the variable voltage motor driving the commutator or interrupter of the high tension set as shown in Figure 8.

Figure 12 illustrates the electrical connections of the vibrators.

Similar reference characters refer to similar parts throughout the several views of the drawings.

Referring to Figures 1 and 2, 5 is a frame for supporting the equipment and 6 is a conveyor belt which may be made of rubberized fabric or rubber. The flock is deposited upon this conveyor belt 6 and carried through the coating device. I provide a flat vibrating screen 7 of suitable mesh according to the type of comminuted material being passed through the screen and I provide electric vibrators 8 to vibrate the screen 7. A rotary sifting screen 9 delivers the flock or other comminuted material to the vibrating screen 7. I provide suitable electrodes 10 which are joined together by conductors, not shown. Roll 11 is driven by a motor, not shown, and continuously drives the conveyor belt around idler rolls 11a in the direction shown by the arrow in Figure 1. I provide a terminal and conducting connection 12 by means of which the electrodes 10 are connected to a source of high potential of suitable characteristics. A conductor 13 connects the vibrating screen 7 to ground. I provide a feed hopper 14 from which the flock or other comminuted material is supplied to a screw feeder 15 which in turn delivers the comminuted material to the rotary sifting screen 9. The rotary screen 9 and the screw conveyor 15 may be driven by a motor 16 driving a belt 17 which drives a pulley 18 attached to the shaft of the rotary screen 9 and screw feeder 15. I provide a suitably mounted roll of fabric 19 or other material which is to be coated with flocks or other comminuted materials. The fabric 19 is drawn over a plurality of idler rolls 20 in a course which may be as shown, by means of any suitable take-up device as a suction dsum, not shown. I provide a set of electrodes 21 which may or may not be insulated and which are connected together by suitable conductors 22. A terminal and connection 23 are provided to connect electrodes 21 to a suitable source of high potential having the desired characteristics as set forth herein. I further provide another set of coating electrodes 24 and these electrodes 24 may be joined together by suitable conductors 25. The electrodes 24 may be grounded as indicated at 26. The fabric 19 is coated with adhesive as by means of a suitable set of coating rolls 27 and an adhesive trough 28 and is conducted between the electrodes which at least equal in width (Figure 1a) the fabric to be coated.

The flock or other comminuted material is introduced into the hopper 14 of Figures 1 and 2 and delivered by the screw conveyor 15 to the rotary sifting screen 9 which in turn delivers the comminuted material to the flat vibrating screen 7. The flock passes through the vibrating screen

7 and is jerked apart and uniformly distributed over the conveyor belt 6 by the electrostatic field set up between electrodes 10 and 7, the vibrating screen 7 being a grounded electrode. The conveyor belt 6 continuously carries the flock between the coating electrodes 21 and 24. The fabric 19 passes over the idler rolls 20 between the coating rolls 27 where a suitable adhesive such as, for example, rubber cement is applied to the fabric from the coating trough 28. Fabric 19 continues over the idler rolls 20 between the coating electrodes 21 and 24 where the flocks or other comminuted materials are propelled into the adhesive coating on the fabric 19. The coated fabric continues over idler rolls 20 being pulled by a suction drum, as mentioned, and is delivered to festooning racks or other suitable drying equipment.

Referring to Figures 3 and 4, numbers 5–39 inc. denote parts identical with the parts denoted by the same numerals in Figures 1 and 2. Figures 3 and 4 illustrate how the advantages of feeding flock by an air current or other gaseous medium may be combined with the other advantages disclosed in Figures 1 and 2. In Figures 3 and 4, 39 denotes a feed hopper into which the flock that is used in the coating process may be introduced. The numeral 30 represents a hinged cover for the feed hopper 39. In these figures 31 is an air intake and 32 is an air duct that connects feed hopper 39 to a blower 33 which is used to propel the air current with the flocks entrained therein. Pipe 40 is an air duct extending from blower 33 to a centrifugal collector 36. The numeral 34 represents a motor which drives the blower 33 through suitable connecting means. Pipe 36 is a discharge extending from the centrifugal collector 36 to the feed hopper 16 whereby the flocks are conveyed from the collector to the hopper. Pipe 37 is an exhaust from the centrifugal collector 36 and the size of the exhaust pipe may be varied as desired, depending upon the material being used and the rate at which air is blown into the collector. I may provide a surplus hopper 38 in which the case the flocks not coated onto the adhesive on the fabric 19 are dumped into the belt 6 into the surplus hopper 38. From the surplus hopper 38 the surplus flock collected may pass through duct 35 into the air stream of duct 32 for recirculation along with additional flock added through hopper 39 or the surplus flock may be retained in hopper 38 and removed from time to time whereby only the new flock added through hopper 39 is coated.

Referring to Figure 5, 6a denotes the belt trained about idler rolls 11a and driven by the motor-driven roll 11 in the direction indicated by the arrow. Part 7 is the flat vibrating screen to which are attached the vibrators 8. The flat vibrating screen 7 serves as an electrode and is grounded as indicated by 13. The rotary sifting screen 9 is fed, for example, by a screw conveyor as illustrated in Figures 1 and 2 and the flock passes from the rotary screen 9 to the flat vibrating screen 7. Numerals 10a represent electrodes which may be insulated and joined together by suitable conductors 22a. Electrodes 10a are provided with a terminal and connection 12 to a high tension set. The flocks pass through flat vibrating screen 7 into the electrostatic field set up between the electrodes 10a and the flat vibrating screen 7 which is also an electrode. In this field the flocks are broken up and loosened and prepared for the subsequent operation. I provide a set of electrodes 21a which may or may not be insulated and which are connected by suitable conductors 22b. A terminal and connection 23a connects electrodes 24a with a source of high potential of suitable characteristics. Numeral 24a represents another set of electrodes located above the belt 6a. These electrodes may or may not be insulated and are joined together by suitable conductors 22a. Electrodes 24a are grounded as indicated at 25a. The flock passes from the electrostatic field set up between electrodes 10a and flat vibrating screen 7 into the electrostatic field set up between the electrodes 21a and 24a. In this latter field the flocks are oriented on the belt substantially perpendicular to the surface of the belt and are thereby rendered more suitable for the subsequent coating operation. A fabric 19 is passed between coating rolls 27 where adhesive is picked up from coating box 28. The adhesively coated fabric 19 then passes over idler rolls 20 and through the electrostatic field set up between electrodes 21 and 24, the flock being delivered into this field in an oriented condition, as previously explained, by endless belt 6a. In the electrostatic field between electrodes 21 and 24 the flock is propelled into and retained by the adhesive coating on fabric 19 and the flock coated fabric passes continuously to some suitable drying arrangement, not shown, being pulled by a suitable suction drum as specified. Terminal, ground connection and connecting conductors are provided as previously specified in the case of the embodiment of Figures 1 and 2.

Referring to Figure 6 which illustrates diagrammatically a set-up for obtaining any desired frequency of pulsation of alternating current and any desired potential from an electrode used in my coating process, 46 is a variable speed motor connected through suitable connecting means 47 to an alternating current variable frequency generator 48. Suitable motors, connections and generators are well known in the art. The alternating current generated in generator 48 is fed through conductors 50 and 51 to the primary winding 49 of a transformer. In conductor 51 between the motor generator and the primary winding 49 of the transformer is located a rheostat 52 for varying the voltage. The transformer may be of any desired type, but for purposes of illustration, I use a core type transformer. A 53 is shown a ground for the secondary winding 54 of the transformer, the secondary winding 54 of the transformer being connected to a suitable conductor 56 which leads to a suitable terminal A± which may be one of the electrodes indicated as connected to a high tension set in Figure 1, 2, 3, 4, and 5 or it may be a terminal which is in turn connected to one of the aforesaid electrodes. By such adjustments as are known in the art, the variable speed motor 46, the generator 48, the transformer windings 49 and 54 and the rheostat 52 may be controlled to obtain any desired frequency and potential at the terminal A±.

Figure 7 shows diagrammatically a typical sine curve characteristic of the potential impressed upon the terminal A± of Figure 6.

In Figure 8 is illustrated a set-up suitable for producing a continuous direct current of a desired high potential or an interrupted direct current of the desired potential. In Figure 8, 60 represents the primary winding of a transformer fed by a suitable source of alternating current at the terminals x and y and 61 represents the secondary winding of the transformer. Any suitable transformer may be used, but I generally employ a transformer of the core type. The

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transformer is grounded, as indicated in Figure 8, by a suitable conductor 82. Conductors 83 and 84 run from the secondary winding of the transformer to Kenotron tubes 86 and 86. Conductor 87 runs from Kenotron tube 85 to conductor 88 and conductor 89 runs from Kenotron tube 86 to conductor 88. Conductor 70 is grounded and extends to a terminal (G) which may be the electrodes indicated as grounded in Figures 1, 2, 3, 4 and 5 or an intermediate terminal which is in turn connected to the said electrodes. Conductor 88 leads to a terminal A— which may be the electrodes indicated as connected to a high tension set in Figures 1, 2, 3, 4, and 5, or an intermediate terminal which is, in turn, connected to those electrodes. I provide a condenser 71 connected by suitable conductors to the conductors 88 and 70. The purpose of condenser 71 is to largely eliminate the ripple effect that would otherwise be obtained in the potential delivered to the terminal A—. I provide a commutator 72 located between the two branches of a conductor 73 which runs from conductor 88 to the conductor 70. Commutator 72 is driven by a variable speed motor, not shown. A suitable wiring diagram for a variable speed motor which may be used to drive the commutator or interrupter 72 is shown in Figure 11. Commutator 72 is used only in those cases where a pulsating direct current is desired. When it is desired to have one of the electrodes in Figures 1, 2, 3, 4, and 5 grounded and the opposing electrode of an uninterrupted negative potential, the interrupter 72 is not used. By not using the interrupter 72 and by properly adjusting the transformer and the characteristics of the current delivered to the primary winding 80 by methods well known in the art, I am able to obtain any desired negative potential at the terminal A—. If, instead of a negative potential on one electrode and the other electrode grounded, I desire a positive potential on one electrode and the other electrode grounded, I reverse the Kenotron tubes 85 and 86, that is, the plates of the Kenotron tubes 85 and 86 will be joined to conductors 83 and 84, thus reversing the direction of flow of electrons. Thus, I am able to deliver to the terminal A— either a positive or negative potential of any desired voltage. If, instead of a steady direct potential I desire an interrupted potential, either the positive or negative potential may be interrupted with any desired frequency by operating commutator 72. By varying the time of contact and the time that the contact is broken, I may obtain any desired frequency of interruption and any desired duration of time of the interruptions, and any desired duration of time of the electrical impulses.

In Figure 9, I have illustrated diagrammatically an uninterrupted direct potential. In this figure, 74 represents the base line or zero potential and 75 the applied negative potential which has only a relatively small ripple effect. This ripple effect is not very great because of the action of the condenser 71 of Figure 8.

In Figure 10, I have illustrated the same negative direct potential interrupted. In this figure, 76 represents the base line or zero potential and 77 represents the interrupted negative potential. The potential as illustrated in Figures 9 and 10 are taken from the negative terminal A— of Figure 8. Positive potentials, uninterrupted and interrupted, similar to the negative potentials illustrated in Figures 9 and 10 may be obtained where the Kenotron tubes of Figure 8 are reversed so as to apply a positive potential at the terminal A—.

Referring to Figure 11, 90 is the field winding, 91 is the armature and 92 is a potentiometer used for controlling the armature current, which in turn controls the speed, the greater the current the greater the speed of the motor and vice versa. Potentiometer 92 consists of parts 93 and 94 and 95 is a connection between armature 91 and the resistance 94, 96 making a sliding or other adjustable contact with resistance 94 whereby the current may be increased or decreased at will.

Referring to Figure 12, 80 is the primary of the transformer and 81 is the secondary, the transformer reducing the potential from 110 volts to 10 volts. The secondary of the transformer may be connected to the filament of a Tungar rectifier 82 or other suitable rectifier. The plate of the rectifier 82 is connected to a variable resistance 83 provided with a sliding or other adjustable contact 84 and this variable resistance is used to control the amplitude of the vibrators by controlling the current energizing the vibrators. Windings 94 are the windings for the solenoids of the electric vibrators and 95 are the cores of the vibrators which transmit the mechanical vibration to the first vibrating screen 7 of Figures 1, 2, 3, 4, and 5. The windings 94 of the vibrators are energized, for example, by 110 volt, 60 cycle, single phase A. C. current plus a superimposed pulsating D. C. current supplied by the rectifier 82. The applied D. C. potential serves to unbalance the alternating current wave and causes the cores 95 of the vibrators to move back and forth within the windings 94 of the solenoids. The amplitude of the vibration is regulated by controlling the D. C. voltage and current supplied by rectifier 82 by adjusting sliding contact 84. If the voltage and current are increased, the system becomes more unbalanced and the amplitude of the vibrations is increased. A decrease in the applied D. C. voltage and current, on the contrary, decreases the amplitude. With the arrangement shown the desired amplitude of vibration may be attained. If other frequencies of vibration are desired, different frequencies of alternating current may be supplied to the primary winding of the transformer and to the windings 94 of the solenoids.

The apparatus of the present invention and the different embodiments as above set forth have the following advantageous features:

a. The flock is effectively broken up prior to being coated upon the fabric 10. Under certain conditions of manufacture and humidity, flock as received by the coater is badly matted and it has been difficult effectively to separate the individual fibres. By providing apparatus which separates the fibres effectively before the flock arrives at the final electrostatic field which does the coating, I am enabled to handle material which it has been difficult to use heretofore. The various embodiments of the present invention use one or more apparatus to shake up and separate the flock fibres and the selection of a particular apparatus among those illustrated and described herein may depend upon the type of material being produced, the grade of flock being used and its condition, whether matted or not, and, if so, how much.

The method illustrated in Figure 1 and 2 contemplates using a vibrating screen which constitutes one electrode of an electrostatic field and an auxiliary electrode or electrodes to break up lumps of fibres and separate them into individual

fibres and deposit them evenly on a conveying means for subsequent coating, in oriented relation, on an adhesively coated foundation material.

b. Another feature of the invention is the production of a more uniform coating in the final article. This is dependent to a large extent upon the effectiveness of the dispersion prior to the time the flock enters the final electrostatic field which does the coating. Even though all of the fibres are separated from each other a poor distribution thereof will have a tendency to produce an uneven coating and in order that the textile goods may present a uniform appearance, a uniform coating is desired. As in the case of separation of the fibres, the particular apparatus of those herein disclosed which will be used for a particular coating job depends upon the type of flock which is being used and the condition thereof.

c. A third feature of the invention is the production of a piled fabric in which the individual fibres are maintained to a greater extent in parallelism and more nearly normal to the backing material 10. It is the final electrostatic field which finally orients and coats the fibres prepared for coating by the previous orientation, but a previous electrostatic field gives the final electrostatic field less work to do in this respect and the ultimate result has been found to be superior.

d. Still another feature of the invention involves pre-charging the individual flock fibres so that the final electrostatic field which does the coating finds them more responsive and propels them with greater ease towards the backing material 10. Certain flock materials are hard to lift electrostatically and such materials can be more readily handled by apparatus as herein disclosed than previously. Furthermore, the durability of the fabric produced involves the tenacity with which the pile is attached thereto. This may be a function of the adhesive employed, but with a given adhesive it may also be a function of the force or speed with which the particles are propelled to the backing material 10. By providing apparatus to pre-charge the flocks prior to their entering between the coating electrodes 21 and 24, I am enabled to handle materials which could either not be handled previously or only with difficulty and at a slow rate of production. This advantageous feature may thus also involve an increase in the production of the machine.

In order to attain the advantageous features (a) and (b), that is, to break up and disperse the flock, either direct current or alternating current may be used. I prefer to use either alternating current or a pulsating direct current. In order that a given machine may effectively handle different types and kinds of flock material and under varying conditions of temperature and humidity, both the frequency and the effective E. M. F. should be variable and controllable. I have found that the frequency should have a range of from 2 to 200 cycles per second for alternating current and 2 to 200 impulses per second for pulsating direct current. The effective voltage should range from 5000 to 75,000 volts. However, I do not wish to be limited to any particular range in either respect and the foregoing is given merely to assist one in putting the present invention into practice.

It should be understood that in order to properly break up and disperse the flocks, it is often advantageous to bring about a bounding back and forth between the electrodes which is readily accomplished under the influence of an alternating current or an interrupted direct current superimposed upon the electrodes, as for example, electrodes 18, Figure 1, connected to the source of high potential.

For the accomplishment of feature (c), that is, in order to orient the flock, direct current is preferred and this may or may not be a pulsating or interrupted direct current. The same holds true for the accomplishment of feature (d), that is, for pre-charging the flock particles before they enter the final electrostatic coating field.

In pre-charging or in orienting the particles, the object is not to bounce the particles up and down and separate them as in the case of feature (a), but to charge and orient the particles on the supporting member, as for instance, belt 9a. It will be clear that orientation and alignment will be best accomplished where the fibres are charged and made to stand erect parallel to the lines of force of the field on the supporting member, without being propelled backwards and forwards between the electrodes. The voltages and electrodes spacings required to charge and orient the fibres without propelling them depends upon the conductivity of the comminuted materials, as for instance, flocks, and the conductivity of the supporting belt, both of which may vary with the humidity of the atmosphere. While I cannot give any specific spacings and voltages for a particular instance, the voltages and spacings may be readily adjusted to the point that the comminuted materials or fibres simply stand erect and orient without being propelled toward the opposite electrode. In many cases, good results have been obtained with an electrode spacing of one inch and 20,000 volts. In some instances, an electrode spacing which is not much greater than the length of the fibres will be found effective.

For the accomplishment of feature (d), that is, to cause the flock particles to be impelled with greater force to the fabric 10, the pre-charging electrode should be charged with electricity of the same sign as the electrode of the electrocoating apparatus which is on the same side of the belt 9a where direct current, either uninterrupted or interrupted, is used in coating. On the other hand, this might be varied to the extent of having the pre-charging electrode of opposite sign to the electrode of the coating apparatus which is on the opposite side of the belt 9a. In case the coating is carried out with alternating current, that is, an alternating polarity, pre-charging with either a positive or negative charge is advantageous if the flocks or other comminuted material is a good insulator or very poor conductor, that is, if the flow of electrons through the material or over its surface is relatively slow as compared with the speed of reversal of the polarity of the coating electrodes. The bottom electrodes in the various embodiments of this invention have been shown as connected to the high tension terminal of a source of high potential, and the upper electrodes have been shown as connected to ground. This is a preferred arrangement, but very satisfactory results may also be attained when the connections are reversed, that is, when the upper electrodes are connected to a source of high potential and the lower electrodes are grounded. It is particularly important that the upper electrodes in contact

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with a fabric coated with a conductive adhesive be grounded.

The rotating screen 9 is effective to break up clumps of the flock which are further broken up by the vibrating screen 7. With the use of the apparatus shown in Figure 3, the flocks come to the rotating screen 9 fairly well broken up. This blower apparatus may, therefore, be used in cases where the flock is badly matted. The centrifugal blower 32 acts to break up the flock material both by reason of the air stream and also by the impact of the blades of the blower upon the material.

The electrostatic field between the electrodes 18a and the screen 7 in Figure 3 has the function of separating the flock fibres still further and distributing them uniformly on the belt 6a. The electrodes 21a and 24a cause a charging and/or orienting of the fibres on the belt 6a as well as providing an initial charge upon the fibres so that the final set of electrodes 21 and 24 which do the coating will transfer the particles more effectively in oriented relation into the adhesive and produce a superior coating.

By means of the apparatus and methods illustrated in Figure 3, I am therefore enabled to form on a supporting member, a layer of fibres in oriented relation and in contact with the supporting member and thereafter transfer the oriented layer of fibres in oriented relationship to an adhesively coated backing.

Certain types of materials are so conductive as to be handled with difficulty and other types of materials are so near being perfect insulators as to present great difficulty also. I may condition the atmosphere passing through the blower 32 or in the coating room to increase or lower the conductivity of the flocks, as, for example, by using an atmosphere of controlled humidity, that is to say, I may use greater or less humidity than that prevailing outside at the particular time, as desired.

It will thus be seen that there has been provided by this invention, apparatus in which the various objects hereinabove set forth, together with many thorough practical advantages, are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention, and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. Apparatus for coating a foundation material with comminuted material, such as flocks, comprising a vibratory screen, means for establishing an electrostatic field in which the screen constitutes one electrode, means for delivering comminuted material to the screen, whereby material sifted through the screen is charged with a potential different from that of the screen, a conveyor for conducting from the field the comminuted material sifted through the screen, the charges imparted to the material by the field serving to separate and disperse the material on the conveyor, a pair of electrodes for establishing an electrostatic field, means for passing said conveyor with the comminuted material in dispersed condition thereon between said electrodes, means for supplying adhesively coated foundation material in spaced relation to the conveyor between the electrodes and means for imparting to the electrode behind the conveyor and remote from the foundation material a charge of the same polarity as the comminuted material, whereby the separated and dispersed material on the conveyor is propelled onto the adhesively coated foundation material.

2. Apparatus for feeding comminuted material, such as flocks, comprising a vibratory screen, means for establishing an electrostatic field in which the screen constitutes one electrode, means for delivering comminuted material to the screen, conveyor means for conducting from the field comminuted material sifted through the screen, the field serving to disperse the material, means for establishing an electrostatic field through which the dispersed material is conveyed and whereby the material is oriented on said conveyor, means for supplying adhesively coated foundation material with the adhesively coated surface facing the material on the conveyor in proximity thereto, and a pair of electrodes for creating an electrostatic field for projecting the material from the conveyor onto said adhesively coated surface.

3. Apparatus for feeding comminuted material, such as flocks, comprising a vibratory screen, means for establishing an electrostatic field in which the screen constitutes one electrode, means for delivering comminuted material to the screen, and conveyor means for conducting from the field comminuted material sifted through the screen, the field serving to impart to the material electrostatic charges of like polarity to disperse the particles on the conveyor, means for establishing an electrostatic field through which the dispersed material is conveyed by said conveyor and whereby the material is oriented and additionally charged on said conveyor means, means for positioning adhesively coated foundation material in proximity to the oriented and charged comminuted material on said conveyor means, and means for establishing another electrostatic field for projecting the oriented and charged particles from the conveyor means onto the adhesively coated foundation material and including a projecting electrode having the same polarity as the charged particles.

4. Apparatus for handling comminuted material, such as flocks, comprising means for creating an air stream, means for delivering the comminuted material into the stream, a collector, means for directing the air stream with the entrained material into the collector, sifting means for receiving the flocks from the collector, means for receiving the flocks from the sifting means, means for electrically charging the flocks for dispersing the same on said receiving means, said receiving means serving to conduct the material along a predetermined path, means for positioning an adhesively coated foundation material in closely spaced proximity to said path and means for creating an electrostatic field for projecting the material from the receiving means to the adhesively coated foundation material in proximity thereto.

5. In an apparatus for depositing comminuted, pile-surface-forming material upon an adhesively coated backing sheet, a conveyor for conveying a layer of such material into proximity to the adhesively coated backing sheet, means for sifting said material onto the conveyor, means for delivering the material to the sifting means, means for breaking up bunches or clusters of the material and for dispersing the same evenly on the conveyor, and means for transferring the dispersed comminuted material from the conveyor onto the backing sheet, said breaking-up

and dispersing means comprising an electrode below and adjacent the conveyor and means for establishing an electrostatic field between the sifting means and said electrode, whereby electrostatic charges of like polarity are imparted to the particles of material and the bunches or clusters are broken up and the particles dispersed by the mutually repellent forces resulting from said charges.

6. In an apparatus for depositing comminuted, pile-surface-forming material upon an adhesively coated backing sheet, a conveyor for conveying a layer of such material into proximity to the adhesively coated backing sheet, means for sifting said material onto the conveyor, means for breaking up bunches or clusters of the material and for dispersing the same evenly on the conveyor, and means for transferring the dispersed comminuted material from the conveyor onto the backing sheet, said breaking-up and dispersing means comprising an electrode below the conveyor and means for establishing an electrostatic field of alternating polarity between the sifting means and said electrode, whereby electrostatic charges of like polarity are momentarily imparted to the particles and the bunches or clusters are broken up and the particles dispersed by the mutually repellent forces resulting from said charges.

7. An apparatus for depositing a coating of pile-forming fibres in oriented relation upon an adhesively coated backing sheet, comprising means for moving such a backing sheet along a predetermined path with the adhesive coating facing downwardly, a conveyor trained for movement below the backing sheet in proximity thereto, means for sifting a layer of comminuted pile-forming fibres on the conveyor, an electrode below the sifting means, means for establishing an electrostatic field of alternating polarity between the sifting means and said electrode to impart electrostatic charges of like polarity to the particles momentarily and thereby break up bunches or clusters of particles and disperse the same by the mutually repellent forces resulting from said charges, a pair of electrodes spaced from the first-mentioned electrode and between which the backing sheet and the conveyor are moved, and means for establishing a second electrostatic field of alternating polarity between the last-mentioned electrodes, whereby the dispersed particles on the conveyor are projected onto the adhesively coated surface of the backing sheet in oriented relation.

8. An apparatus for depositing a coating of pile-forming fibres in oriented relation upon an adhesively coated backing sheet, comprising means for moving such a backing sheet along a predetermined path with the adhesive coating facing downwardly, a conveyor trained for movement below the backing sheet in proximity thereto, means for depositing a layer of comminuted pile-forming fibres on the conveyor, means for establishing a preliminary electrostatic field of alternating polarity to impart electrostatic charges of like polarity to the particles momentarily and thereby break up bunches or clusters of particles and disperse the same on the conveyor by the mutually repellent forces resulting from said charges, a pair of electrodes spaced from the first-mentioned electrostatic field and between which the backing sheet and the conveyor are moved, and means for establishing a second electrostatic field of alternating polarity between said electrodes, whereby the dispersed particles on the conveyor are projected onto the adhesively coated surface of the backing sheet in oriented relation.

9. An apparatus as specified in claim 8 in which the sifting means includes a vibratory screen and in which means are provided to create an electrical field between a pair of electrodes, one of which is constituted by the screen.

10. Apparatus as specified in claim 8 in which the means for delivering the comminuted material to the sifting means comprises an air conduit including means for forming an air stream, and means for introducing comminuted material into the conduit.

11. Apparatus as specified in claim 8 in which the means for delivering the comminuted material to the sifting means comprises an air conduit including means for forming an air stream, and means for introducing comminuted material into the conduit, and in which the sifting means includes a vibratory screen to which the material is delivered, and means for creating an electrical field between a pair of electrodes, one of which is constituted by the screen.

12. In an apparatus for depositing comminuted, pile-surface forming material upon an adhesively coated backing sheet, a conveyor for conveying a layer of such material into proximity to the adhesively coated backing sheet, and means for breaking-up bunches or clusters of such material and for depositing the same in evenly dispersed condition on the conveyor, the last-mentioned means comprising a vibrating screen above the conveyor, an electrode below the conveyor, means for delivering comminuted material to the screen, and means for establishing between the screen and the lower electrode, an electrostatic field of alternating polarity, whereby electrostatic charges of like polarity are momentarily imparted to the particles and the bunches or clusters are broken up and the particles dispersed by the mutually repellent forces resulting from said charges.

JOHN O. AMSTUT.

[fol. 786]

8

CERTIFICATE OF CORRECTION.

Patent No. 2,356,489. August 22, 1944.

JOHN O. AMSTUZ.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, first column, line 45, before the word "case" strike out "the"; line 46, after "dumped" strike out "into" and insert instead --from--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of November, A. D. 1944.

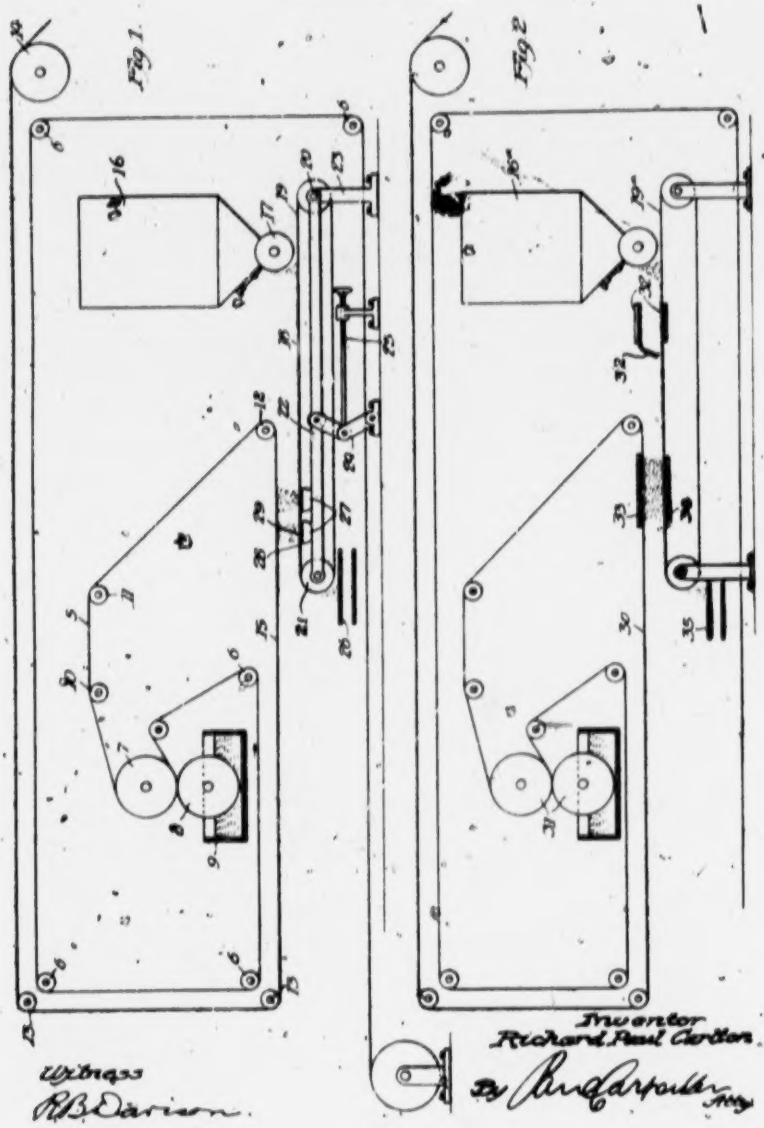
(Seal)

Leslie Frazer
Acting Commissioner of Patents.

March 6, 1945. R. P. CARLTON 2,370,636

MANUFACTURE OF ABRASIVES

Filed March 23, 1933 6 Sheets-Sheet 1



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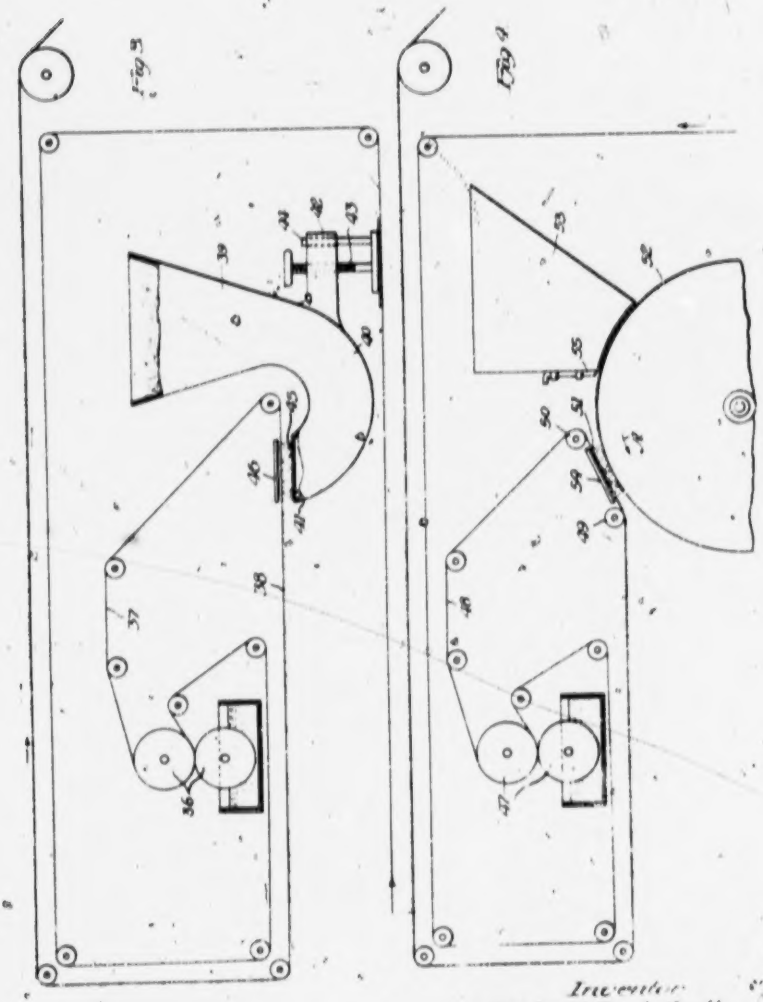
March 6, 1945. R. P. CARLTON 2,370,636

MANUFACTURE OF ABRASIVES

Filed March 23, 1933 6 Sheets-Sheet 2



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MANUFACTURE OF ABRASIVES

Filed March 23, 1933 5 Sheets-Sheet 3

Fig. 5

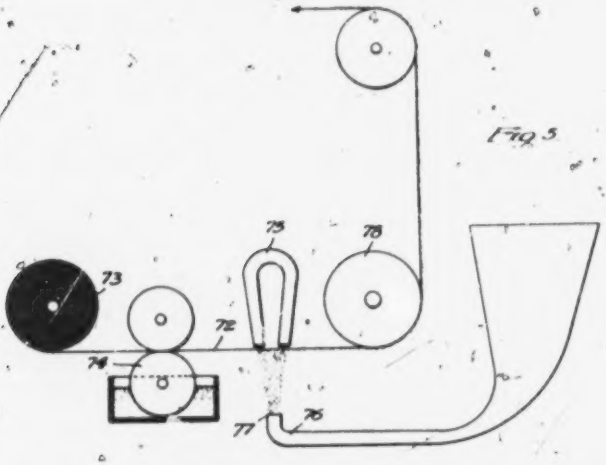


Fig. 6

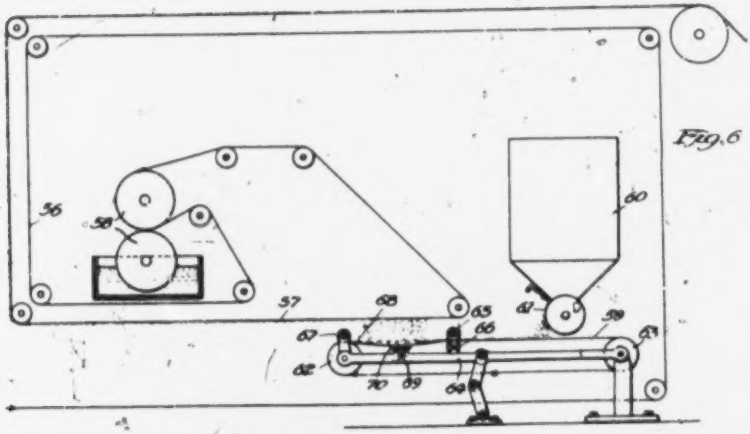
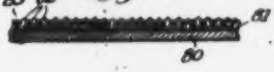


Fig. 7



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March 6, 1945. R. P. CARLTON 2,370,636

MANUFACTURE OF ABRASIVES

Filed March 23, 1933 6 Sheets-Sheet 4

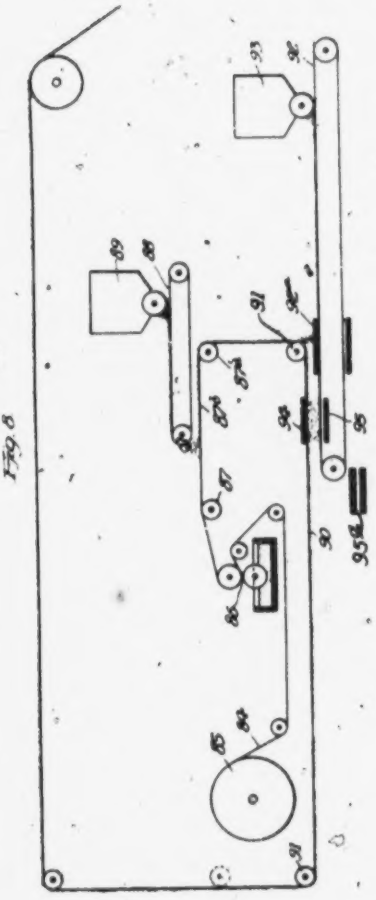

Fig. 8

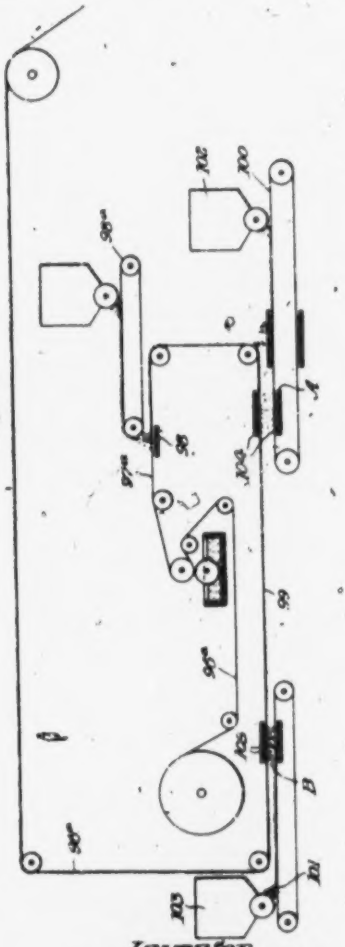

Fig. 9

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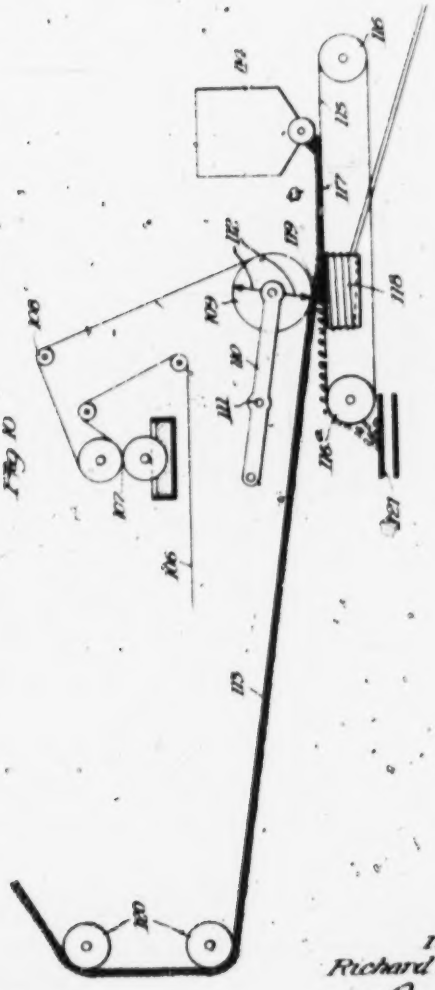
March 6, 1945. R. P. CARLTON 2,370,636

MANUFACTURE OF ABRASIVES

Filed March 23, 1933 6 Sheets-Sheet 5



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March 6, 1945. R. P. CARLTON 2,370,636

MANUFACTURE OF ABRASIVES

Filed March 23, 1933 6 Sheets-Sheet 6

Fig. 11

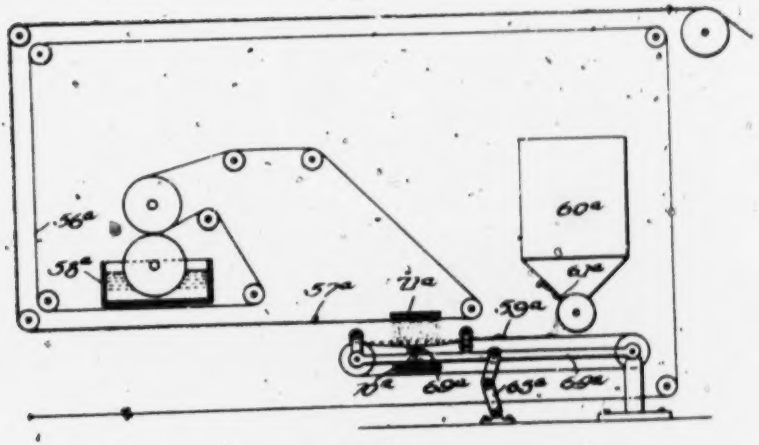
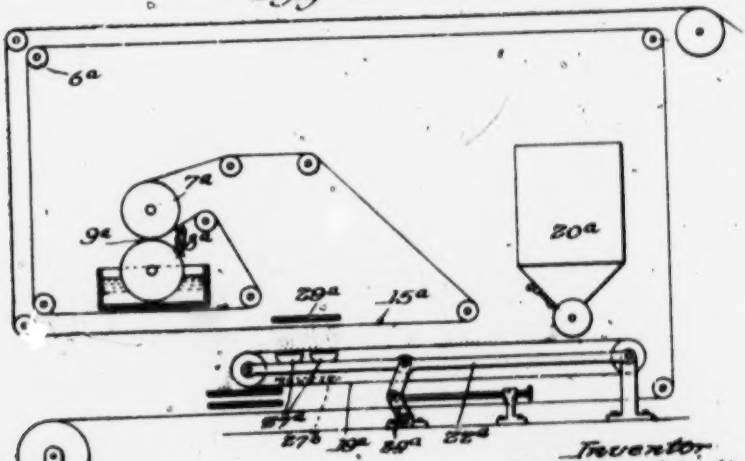


Fig. 12



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Patented Mar. 6, 1945 2,370,636

UNITED STATES PATENT OFFICE

2,370,636

MANUFACTURE OF ABRASIVES

Richard Paul Carlton, St. Paul, Minn., assignor to Minnesota Mining & Manufacturing Company, Wilmington, Del., a corporation of Delaware

Application March 23, 1933, Serial No. 662,219

1 Claim. (Cl. 117—17)

This invention relates in general to coated articles and to the art of coating, and more particularly to an improved method of and apparatus for applying pulverulent coatings to suitably adhesively coated surfaces, and while the invention finds particular utility in the art of making flexible abrasives, and is, therefore, described and illustrated for this purpose, it finds a wide field of utility for analogous purposes.

This application is a continuation in part of my application S. N. 422,965, filed January 20, 1930, now Patent No. 2,318,572, granted May 4, 1943. Said parent application being directed to methods of and apparatus for applying coatings such as abrasive particles to a suitable backing by the action of an electrical field broadly, and in certain respects more particularly in applying such coatings of abrasive particles by the action of an electrical field irrespective of the force of gravity.

It is well known that in the art of making sandpaper, emery paper or cloth and similar abrasive articles, a flexible or in some cases, a rigid, backing of paper, cloth, wood or the like, is employed, to which is applied a coating of an adhesive substance, such as animal or vegetable glue, or where a waterproof article is desired, the backing may be coated with any of the now well known waterproof adhesives of the Okie Patents 1,863,027, 1,863,028, of Dec. 8, 1926, or 1,861,897 of April 30, 1926, for this purpose, and while the coating is still wet or tacky, a suitable abrasive material such as garnet, corundum, sand or the like is applied thereto. The grains of abrasive substances are usually applied by gravity upon the upper adhesive coated surface of the backing and they lie in the adhesive material in haphazard fashion due to the elongated nature of the abrasive particles, and, in a large degree, the facets or cutting edges of the individual grains or grits often lie flat upon or are embedded in the adhesive coating in such a manner that in some instances their best cutting edges never come into contact with the work or, at best, are brought insufficiently into contact therewith. The invention here has as one of its objects to measureably increase the number of grits whose longer or greater dimensions are in a plane perpendicular to the surface of the backing, thereby to present more efficiently the cutting edges to the work, and increase the cutting ability and life of the abrasive article.

It will be understood that in ordinarily depositing mineral, that is, pulverulent abrasive material solely under the force of gravity onto a backing, it acquires a velocity due to the action of gravity. As the grits pass through the intervening air space, there will be caused some change in their positions enroute to the sheet or backing, but ordinarily neither the velocity given to the grits or the effect of the air on them is sufficient to cause them to become aligned so as to assume positions substantially perpendicular to the backing. It is, therefore, necessary that independent force be applied to the grits, and I have found that by passing the grits through a static field of electric energy or of electro-magnetic energy or by mechanically imparting this force to the grits, a much greater number of the individual particles will assume erect positions on the backing, which will enhance its cutting ability. As will later appear, my invention, in its several forms, is capable of application for operation in conjunction with gravity methods of applying the grit, inasmuch as under certain conditions, and for some purposes, it is desirable to employ both gravity and one of the forms of my invention in conjunction in order to attain a desired form of abrasive article.

In carrying out this invention, I find it desirable to employ a conveyor for conducting the mineral at fast relative to the conveyor by relatively slow speed to a point adjacent to which the independent force is applied for projecting the particles of grit onto the backing. I find that by then applying this independent force, be it mechanical or electrostatic or electromagnetic, I am able to impart a high velocity to the particle so that any force of gravity acting on the particle, whether in the same direction, in a counter direction, or in a direction angularly to that at which the force is applied, will be relatively small compared to this force applied. It is possible with the present invention to apply the force directly counter to gravity, that is, by bringing the grits beneath the backing or by applying the force in some other direction as long as the force of gravity and the effect of air is reduced below a point which will interfere with the result desired, namely, the projection of the grits with their longitudinal dimensions ultimately perpendicular, or substantially so, with respect to the backing.

The principal objects and advantages of this invention reside in the provision of an improved abrasive coated article, such, for example, as sandpaper, emery cloth, or the like, wherein the abrasive grits or grains lie in position on the backing for increasing the cutting effect and durability of the abrasive article; the provision of an improved abrasive article wherein the ab-

[fol. 794]

rasive grits are disposed so that their cutting facets are presented in position to more efficiently engage the work and thereby produce a sharper article; the provision of an improved abrasive article wherein the abrasive grains or grits are applied thereto with their longer or greater dimension substantially perpendicular to the plane of the backing; the provision of an improved abrasive article which may be flexible or rigid, as desired, and which may or may not be made waterproof, that is, suitable for employment in a water abrading operation.

This invention further includes as objects and advantages thereof, the provision of an improved method of and apparatus for manufacturing abrasive articles; the provision of an improved method of and apparatus for applying pulverulent material to one surface of a backing irrespective of the force of gravity, that is, against the normal tendency of the force of gravity; the provision of an improved method of and apparatus for propelling a pulverulent material, such as a grit or an abrasive grain, against an adhesive coated surface; the provision of an improved method of and apparatus for the purpose set forth and including electrically operated means for acting on an abrasive grain or pulverulent material and causing it to advance onto the adhesive coated backing irrespective of the force of gravity; the provision of an improved method of and apparatus for causing the particles of pulverulent material to impinge upon and assume a position in the adhesive coated surface substantially normal or perpendicular to the surface of the backing; the provision of an improved method of and apparatus for propelling a pulverulent material onto a moving sheet in a direction transversely to the plane of movement thereof and in a direction substantially counter to gravity; the provision of an improved method of and apparatus for making abrasive articles, such as sandpaper and the like, which includes the application of a grit to the under side of the backing; the provision of an improved apparatus which includes means for feeding and applying a pulverulent material counter to the force of gravity and simultaneously with movement of the backing; the provision of an improved means for moving a web of paper and applying an adhesive thereto and including means arranged below and for operating synchronously with for applying a pulverulent material to the under side of said moving backing; and the provision of an apparatus of the character described wherein improved electrostatic or electromagnetic means may be employed, acting on the abrasive material and causing it to move at an accelerated speed toward the sheet so as to cause it to impinge thereon in the adhesive coating and thereby present the cutting edges of the abrasive grits away from the surface of the backing and thus increase the cutting ability and life of the abrasive article.

I have also found my invention useful as a modifying step in the employment of the conventional gravity process for applying grit in the manufacture of sandpaper or other abrasive, and, therefore, additional objects of this invention reside in the provision of an improved method of interposing an additional step which will apply abrasive grains either before or after the application of grits by gravity in the usual manner, it being understood that the step of applying grit irrespective of gravity by an electromagnetic or electrostatic means may be employed somewhere in the process of manufacture, the essential purpose being to increase the number of grits whose cutting facets are presented away from the backing and thereby to enhance the cutting ability of the finished article.

The apparatus of this invention includes a number of alternative forms for mechanically or electrically carrying out the steps of the process and to this end is provided an improved pneumatic means and improved vibrator structure for mechanically propelling the pulverulent materials and improved electromagnetic structure for acting on the mineral and causing it to move in a cloud toward the adhesive coated surface of the moving web or backing.

The foregoing and such other objects and advantages as may appear or be pointed out as this description proceeds are attained in the structures illustrated in the accompanying drawings in which:

Figure 1 is a schematic view illustrating one form of apparatus for carrying out the process of this invention;

Figure 2 is a view similar to Figure 1 of an alternative form of the invention;

Figures 3, 4 and 5 are further alternative forms of the invention which include the electrical feature;

Figure 6 is a further alternative form of the apparatus of this invention for employing vibrating means;

Figure 7 is an enlarged schematic view illustrating a portion of an abrasive article made in accordance with this invention;

Figures 8 and 9 are additional alternative forms of apparatus for carrying out further steps of the process of this invention;

Figure 10 is a further alternative form of apparatus for carrying out one of the methods of this invention; and

Figures 11 and 12 are further alternative forms for carrying out additional methods of the present invention.

The method of the present invention includes as steps thereof the feeding of a web or strip of paper or other fabric at a predetermined rate of speed, applying an adhesive substance to the under side of the sheet, or applying the adhesive coating to one side and then moving the sheet with the coated side out, and simultaneously with the movement of the coated sheet causing a grit or abrasive material to be applied to this side. The sheet or web of paper may be moved so that the adhesive coated side is either presented downwardly or at any angle thereto. The movement of the abrasive grains onto the under side of the backing is done irrespective of the force of gravity and, in fact, directly counter to gravity, and preferably done by imparting relatively high velocity to the abrasive material, thus causing it to impinge upon the adhesive coating. In view of the fact that the abrasive grains are projected through an intervening space from a suitable carrier on to the adhesive coated side irrespective of or counter to the force of gravity, the grains, which are usually somewhat elongated, will assume a position in transit so that the longer dimension thereof will take a position normal to the surface of the backing, thus causing the grains to "stand" on the surface rather than lie flat in greater percentage than when they are deposited by gravity. It is to be understood that this movement of the grains and deposition of them on the coated surface may be carried out in a number of ways.

either by vibration, by an airblast, or by electrostatic or electromagnetic means.

In the alternative forms of this invention later to be described, the method involved includes combining a gravity deposition of mineral on the adhesively coated moving backing with the step of applying the grits irrespective of gravity, this being particularly useful in some of the heavier grits wherein it may be found that the force susceptible of application by an electrostatic or an electromagnetic means is not sufficiently active on the available area of the individual grits to cause an entirely satisfactory result or to move enough of the grits onto the sheet to attain the desired end. In this invention it may be required to apply some of the grit by gravity and later apply some of the grit by one of the methods of this invention or vice versa, but, in any event, the number of grits in the entire finished article which stand erect on the backing will be measureably increased over the ordinary methods heretofore employed for depositing grit on a backing for forming an abrasive article.

This invention produces a very satisfactory piece of sandpaper in which the cutting ability is measurably increased and by the deposition of the grains of sand or grit irrespective of the force of gravity, it is possible to produce an orientation of the mineral as desired and to control the thickness of the abrasive coating much more readily than where gravity alone is relied upon or employed for depositing the grains on the sheet.

The apparatus of this invention may take any one of the forms shown in the drawings and in the form of the invention shown in Figure 1, air pressure is resorted to for producing the mineral cloud and for projecting the mineral onto the moving web.

Referring now more particularly to Figure 1, the flexible backing 6 of paper or cloth or other fabric is trained or fed over a series of rollers 6, 6, and over one of a pair of the squeeze rollers indicated at 7, the other roller 8 of said pair being in contact with an adhesive material contained in a tray or tank 9 by which an adhesive coating is applied to one side of the moving web. After receiving the adhesive coating, the web 6 is trained over rollers 10 and 11 and is brought back over a roller 12 so that the adhesive coated surface of said web is presented downwardly. The web may then be trained over rollers 13, 13, and fed to a suction drum 14, whence it passes into festoons for drying.

The mineral is supplied from a hopper 16 and a conventional outlet 17 which feeds a layer 18 of mineral to a moving conveyor 19. This conveyor 19 is preferably porous and passes over the feeding rollers 20 and 21 and is adapted to move at a suitable rate of speed to supply a sufficient quantity of abrasive grain. In some cases, it has been found advantageous to move the conveyor at a speed substantially the same rate of speed as the web 15, although these speeds are, of course, variables. The rollers 20 and 21 are mounted in the ends of a suitable frame 22 and this frame may be raised and lowered so as to vary the distance between mineral conveyor 19 and the moving web 15. This frame 22 may be supported fixedly at one end, as indicated at 23, and the other end may be raised and lowered by a toggle arrangement 24 activated by a threaded rod 25. Below the conveyor 19 and at the movable end thereof, that is, adjacent to the web 15, there is provided a second conveyor 26 which serves to conduct away excess mineral which flows over the end of the conveyor 19 and which may be returned in any suitable manner to the mineral hopper.

Below the upper flight of the conveyor 19, there are provided two air troughs 27. These air troughs are provided with flat upper walls 28, having slots 29 therein, said slots extending across the width of conveyor 19 and the troughs themselves being connected to a suitable source of air under pressure.

These troughs form in effect elongated jets or nozzles and when so placed below the conveyor belt or frame 22, a small quantity of air is emitted at high velocity which passes through the porous belt or conveyor.

It will be understood that when a blast or blasts of air are delivered from the troughs 27, this blast of air passes through the porous conveyor 19 and blows the mineral from the conveyor against the under side of the flight 18 so that the mineral is caused to strike into the adhesive at a relatively high velocity and become impinged therein. Owing to the projecting of the mineral in this manner through the intervening air space, the individual particles of grit or abrasive material are caused to assume a position parallel to their trajectory, that is, with their longer dimension perpendicular to the surface of the flight 18. In view of the fact that most of the particles of mineral are somewhat elongated due to the manner of production of the same, they will naturally assume this position in movement from the conveyor 19 to the adhesive coated surface of the backing. As they arrive at the adhesive material, they impinge themselves thereon and will thus stand erect in the adhesive, thus forming a sharper contour for abrasive purposes. By varying the rate of speed of the moving backing relatively to the speed of the conveyor and by varying the distance between the conveyor and the backing and the velocity of the air stream, and by increasing or reducing the number of such jets and the quantity of adhesive applied, any reasonable desired thickness of grit layer may be produced during the process and without stopping the apparatus. It will be understood that the excess mineral carried by the conveyor may be dumped into the conveyor 26 and returned by any suitable means to the hopper 16.

Referring now to Figure 3, there is provided the same general arrangement of moving backing, having the flight 30 adhesively coated from the squeeze rollers 31.

Below the flight 30 there is provided a mineral feeding conveyor 19a, receiving pulverulent material from the hopper 16a.

The conveyor 19a is mounted for movement toward and away from the flight 30 similar to the conveyor 19 and, therefore, this structure has not been shown in Figure 2.

As the mineral flows from the hopper 16a it does not always assume a smooth or even distribution on the conveyor 19A, and therefore, it may be desirable to provide a pair of charged electrodes 32, one arranged above and one below the conveyor 19A, for the purpose of spreading the mineral evenly on the conveyor belt. The conveyor 19A in this instance may be non-porous.

When charged electrodes are put in this position they act in principle the same as the charged electrodes used for coating the mineral on the backing. An electrical charge or difference of potential is set up between the electrodes 32. The

[fol. 796]

voltage or difference in potential between those electrodes is maintained great enough to produce a strong static field, but not so great as to break down the insulation between the plates, which insulation may be the dielectric strength of the air or the dielectric strength of the air plus the dielectric strength of any insulating material which may be used to wrap the electrodes.

As the mineral on the conveyor enters the static field between the plates the mineral particles take on the charge of the lower plate, and are repelled to the upper plate where they lose their charge and take on the opposite charge of the upper plate. At this point they are repelled to the lower plate. Since new mineral is being conveyed by the conveyor into the field continuously the static fields soon become supersaturated with mineral particles, and an equilibrium is reached where as many particles are thrown out of the static field as are brought in by the conveyor. By having a down-turned end 32A of the upper electrode the mineral particles that are thrown out of the static field are deflected evenly on the conveyor belt so that a smooth coating of abrasive grit is first placed on the conveyor.

The use of a static field for getting a smooth coating of mineral on the conveyor belt is not necessary to the invention but is an additional means of obtaining evenly distributed abrasive coatings, and is also a means for avoiding the use of any excess mineral on the conveyor. When the mineral is evenly coated on the conveyor at the time it is being coated streaks, thin spots, etc., in the finished product are reduced.

At the same approximate point at which troughs 27 are provided in Figure 1 there are here provided electrically charged electrodes 33 and 34, the electrode 34 being located below the upper flight of the conveyor belt 19A and electrode 33 being disposed above the flight 38 of the backing. A sufficient difference of potential is maintained at electrodes 33 and 34 to produce a strong static field, similarly to that referred to above. This static field moves the mineral from the belt 19A to the underside, which is the adhesive coated surface of the flight 38.

As the mineral enters the static field between the electrodes 33 and 34 it becomes charged with the charge of the lower plate, and is here propelled to the upper plate 33.

It will be observed that in this method of coating the mineral is applied by a force other than gravity. In all other methods of coating sandpaper, known to me, the velocity of the particle is either in whole or part given to it by the force of gravity. In the case of this electrostatic coating the particles are oriented in the static field so that there is a tendency for the long dimension of the mineral to be perpendicular to the electrode plates, and also perpendicular to the web 38, which is being coated. The finished sandpaper product, therefore, contains a substantial percentage of the particles of mineral standing on end rather than laying flat, thereby increasing the cutting properties of the abrasive article.

Excess mineral is dumped onto the conveyor 36, whence it may be returned to the hopper 18a.

Referring now to the alternative form of the invention shown in Figure 3, there are provided the squeeze rollers 36 which apply adhesive to one surface of the moving paper web 37 and the adhesive coated surface thereof is presented downwardly in the flight 38.

In this instance there is provided a hopper 39, having a curved outlet spout 40 whose outlet 41 is presented below the moving web 38. The hopper may be provided with a bracket 42 whereby to receive a threaded member 43, said bracket engaging a guide post 44. In this manner, the hopper may be raised or lowered so as to vary the distance of the outlet 41 from the flight 38 of the backing. A suitable screen 45 may or may not be provided over the outlet so as to cause the distribution of the mineral contained in the hopper. In this instance, the mineral flows by gravity to the outlet 41, but does not pass from the outlet to the adhesive coated backing by gravity, but under the effect of the static charge established between the electrode 46 and the hopper or the screen 45 of said hopper.

The operation of the invention here is much like that of Figure 2, the screen 45 serving the purpose of distributing the mineral and at the same time preventing the large body of mineral in the hopper from forcing it against the coated surface of the backing.

Referring now to the form of the invention shown in Figure 4, there is provided the adhesive coating rollers 47, applying an adhesive coating to one surface of the moving web 48. This web 48 is trained over rollers 49 and 50 so that flight 51 thereof between said rollers is presented in a plane tangential to the surface of a conveyor drum 52 whose lineal velocity is sufficient to furnish the required amount of mineral. This drum is fed from a hopper 53 and forms one electrode of the electrostatic system. The other electrode is indicated at 54 and is disposed above the flight 51. As mineral issues from the gate 55 of the hopper, the drum rotating in the direction of the arrow a, the mineral is carried to a point adjacent to the flight 51 whereupon the electrostatic charge set up between the drum 52 and the electrode 54 will cause a projection of the mineral from the drum onto the coated surface of the flight 51.

Referring now to the alternative form of the invention shown in Figure 5, there is employed here electromagnetic means or a permanent magnet means for moving the grits toward the adhesively coated web. The adhesively coated web is shown at 72 and is fed from a roll 73 over an adhesive coating roller 74. The horizontal flight of the web 72 passes beneath magnet 75 which may be either an electromagnet upon which a variable voltage may be imposed or a permanent magnet.

Immediately below the magnet 75 and the flight 72 of the web, there is provided a source of supply for the mineral, that is, the abrasive material, indicated at 76. This source includes an outlet 77, and the distance between the outlet 77 and the moving web 72 may be varied as desired, or the intensity of the electromagnet, where one is employed, may be varied for changing the thickness of the abrasive coating. The web passes over an idler 78 whence it is fed to festoons not shown.

Referring now to the form of the invention shown in Figure 6, the moving web 86 is trained over a series of rollers similar to the arrangement shown in Figures 1 and 2 so that a horizontal flight 87 of the paper backing is provided, having an adhesive coating on the under side thereof. Squeeze rollers 88 engage the paper backing for applying an adhesive thereto.

In this form of the invention, a mechanical vibrating means is provided which serves to pro-

pel the mineral, that is, the grit, from the grit feeding conveyor 89, which latter receives mineral from the hopper 86, having a gate 91. The conveyor 89 is trained over rollers 92 and 93 mounted in a suitable frame 94, which latter may be mounted for adjustment toward and away from the flight 87 similarly to the conveyor 19 of Figure 1. The conveyor 89 extends below and is separated from the flight 87 of the paper web and travels at substantially the same speed as the paper web.

The conveyor 89 passes between sets of pinch rollers, one above and one below the upper flight of the conveyor 89, as indicated by 95 and 96, and also beneath a pinch roller 97 which bears on the roller 92. The pinch rollers 95 and 96 tend to distribute the mineral evenly over the surface of the conveyor and are so spaced from the rollers 92 and 97 that the portion of the belt 89 between the rollers 95 and 96, and 92 and 97 is permitted to lie slack, whereas the remaining part of the conveyor is substantially taut. This arrangement tends to limit the vibration of the conveyor belt to the zone of application of the mineral to the paper backing, as indicated at 98.

Beneath the portion 98 of the belt 89, there is provided a revolving batter 99 operating on a shaft carried in suitable bearings in the frame 94 and provided with a plurality of radial arms 70 which upon rotation rigidly strike the under side of the portion 98 of the belt, thus throwing or projecting the mineral content thereof against the under side of the adhesive coated paper backing, much in the manner in which the air stream blows the mineral or grit against the paper backing as shown in Figure 1. The batter 69 may be driven in any desired manner from a separate source of power or may be connected suitably with the rollers driving the belt 89, but geared to operate at a greater rate of speed. The rollers 95 and 96 and the roller 97 are separately driven from the belt 89 so as to produce the tautness in the belt, except the flight of the belt indicated at 98.

In Figure 7, there is illustrated an article made in accordance with the present invention. The backing is shown at 99 to which an adhesive coating 81 has been applied, and the grits, greatly enlarged, are indicated at 82 and it is noted that they stand on end in the adhesive coating, thus causing their sharper edges to project beyond the upper or outer surface of the coating, thereby enhancing the cutting ability and increasing the life of the abrasive article. While the article shown in Figure 7 is purely schematic, it will be understood that the mineral actually does take a position substantially normal to the backing and, while all of the grits may not take this position, a large number of the same do and the cutting qualities of the abrasive article are thus greatly increased. Furthermore, by so disposing the grits, it permits of the application of an additional sizing coat or coats to the back and to the front or cutting face of the abrasive material without completely burying the grits and as a thicker coat of adhesive may thus be employed on the cutting face of the abrasive material, the engagement of the adhesive material with the abrasive material is greatly enhanced, thus further tending to increase the life of the abrasive article. Such a sizing coat is indicated at 83.

As previously pointed out where the electrostatic or electromagnetic methods are resorted to in some of the coarser grades of abrasive devices made, it may be found that the electrostatic or magnetic field into which the particles are conducted may not exert on each individual particle sufficient force to cause proper orientation of the particles for the reason that the static effect is substantially proportional to the area of the particle, and the coarser the particle, the smaller the area of effect per weight. Therefore, as larger grits or sizes of particles are employed, increased force is required to move the particle and for some purposes, insufficient increase in force results because of the reduced area per weight. Therefore, in such cases a form of the invention, as shown in Figure 8, may be resorted to wherein the mineral is applied to the adhesively coated backing in part by gravity and in part by electrostatic or electromagnetic means.

In view of the fact that the electrostatic and electromagnetic means may for some purposes be alternatively employed, I have illustrated in Figure 8 merely the electrostatic elements though it will be understood that the electromagnetic means of Figure 5 may be employed in the same manner.

Referring in detail to Figure 8, I have illustrated a web of paper 84 coming off a roll 85 and passing through an adhesive coating device illustrated in general at 86. The web 84 is thence trained over rollers 87, 87a, so that it has a substantially horizontal flight 87b, which receives grits in the desired amount from an ordinary conveyor 88, said conveyor receiving grits from the hopper 89. The web of paper thence is carried downwardly to a horizontal flight 90 by the provision of rollers 91, 91 and adjacent one end of this flight, I provide the conveyor 92 receiving additional grits from the hopper 93, which may be adjustably mounted similar to the conveyors hereinabove described, said conveyor 92 passing beneath the flight 90 of the paper web. As the web passes over the rollers 87a and 91, a quantity of the mineral deposited from the conveyor 88 onto the web will drop off, and, for conveying away this excess mineral, I provide a transversely running conveyor 92a arranged between the flight 90 and the conveyor 92. Beneath the upper flight of the conveyor 92 and above the flight 90 of the web 84, I provide static electrodes 94 and 95, or may provide an electromagnet similar to that shown in Figure 5 which will cause grit coming from the hopper 93 to be applied counter to the force of gravity onto the under surface of the flight 90. A conveyor 96a may be employed for carrying off the excess mineral from the conveyor 92.

In the operation of this form of the invention, it will be understood that a desired proportion of mineral applied by gravity to that applied by force other than gravity may be determined by actual operation so that the desired quantity of the abrasive grits is properly applied to the paper web.

It may be necessary in some of the very coarse grains to additionally apply grit to the moving web and this may be done by providing an additional conveyor similar to that indicated at 92 and additional electrodes, or may be accomplished by additionally applying by gravity grits to the paper web just before it passes on to the festoons.

Figure 9 illustrates the alternative forms suggested in connection with Figure 8, that is, wherein electrostatic or electromagnetic means, or any other means counter to gravity, is employed for applying the grits and in Figure 9 the paper web

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is indicated at 98a having a horizontal flight 97a disposed below a conveyor 98a. In this instance, the grits are deposited from the conveyor 98a by gravity, and the orientation of the grits is assisted by a plate electrode 96. The paper web may then be carried in position so as to provide a horizontal flight 99 and an electrostatic or electromagnetic or other grit applying means for applying grit counter to gravity may be employed at one or more points as indicated at A and B, wherein the conveyors 100 and 101 convey grit from suitable hoppers 102 and 103, and electrodes 104, 104 and 105, 105 serve to apply the grit.

Referring now in detail to Figure 10, there is further illustrated there an apparatus for applying the grit to the adhesively coated backing by an electromagnetic means. In this form of the invention a moving web is provided indicated at 106, this web being a flexible strip of paper which is suitably adhesively coated by a mechanism indicated generally at 107.

The moving web thus adhesively coated is carried over a roller 108, thence over a roller 109, said roller 109 being mounted on a shaft carried in a bearing arm or arms 110 pivotally mounted at 111, whereby the roller 109 may be raised and lowered in the substantially vertical plane of the arrows 112, thus permitting the lower flight 113 of the paper web to be elevated or depressed, as the case may be.

Mineral is deposited from a hopper 114 on to a conveyor 115 trained over rollers 116 and 116a, the upper flight 117 of said conveyor passing beneath the roller 109 and the moving web, and conveying mineral, that is, the grit, to a point adjacent to the roller 109.

Preferably immediately below the axis of the roller 109 and below the upper flight 117 of the conveyor 115 I provide an electromagnet 118 which is so mounted that its magnetic flux passes through the conveyor and causes the mineral particles to stand erect, as indicated at 119, as they move along with the upper flight of the conveyor. While the mineral particles are thus standing erect they come into contact with the adhesively coated side of the paper backing and are thus picked up by it and conveyed away, the backing being trained over rollers 120 and carried to the festoons similarly to the other forms of the invention. It will be observed that the angularity of the lower stretch 113 of the paper web is such that it lies upwardly to the conveyor 115. In this way the particles of grit adhering to the paper are not knocked down by other particles remaining on the conveyor, it being understood that the grit is fed somewhat in excess of the required amount so that an adequate amount will be deposited on the adhesively coated side of the backing. The excess mineral drops off the conveyor 117 and is carried to a collecting means by a conveyor 121.

It will be understood that the amount of mineral fed from the hopper, the strength of the electro magnet, that is, the strength of the flow current transferred and the position of adjustment of the roller 109 may all be properly correlated for obtaining the desired grade of finished article.

It may be desirable that a certain amount of pressure be exerted on the erect particles of mineral so as to cause them to impinge upon the adhesively coated side of the paper and thus by manipulation of the arms 110, an adjustment of the pressure of the roller 109 may be attained.

It will be understood that while the electrostatic and electromagnetic means for coating counter to gravity are illustrated in Figures 8 and 9, the mechanical means hereinabove described may be conveniently employed in these locations without departing from the spirit of the invention. However, the reason the electromagnetic and electrostatic elements are particularly shown here is that the difficulty of counter coating successfully with the coarser grains is more likely to arise with these elements than with the vibrator or air blast heretofore described.

It will be understood that the forms of the invention disclosed herein employing electromagnetic fields are suitable for use with magnetically responsive materials but that other grit or abrasive material may be coated with a magnetically responsive film which would render the grit responsive to the action of the magnetic or electro-magnetic fields.

In the actual production of this invention, particularly where an electrostatic field is employed, some grit sizes require the employment of very high voltages and in employing such high voltages it will be appreciated by those skilled in the art that this involves the construction and installation of special electrical apparatus for producing and maintaining the high voltages, and at the same time necessitates the provision of adequate protection for workmen engaged in the production of sandpaper or the like abrasive article under these conditions.

The form of the invention shown in Figure 3 hereinabove described, is found to be of value in that lower voltages may be employed for producing deposition and orientation of the particles of grit, inasmuch as there is a constant mechanical force exerted on the particles tending to move them toward the sheet to be coated. It is to be noted that the screen disclosed in Figure 3 may be omitted and a controlled supply of the particles to the outlet afforded in any convenient manner. Furthermore, the mounting of the hopper in Figure 3 may be adjusted so that the outlet is moved toward or away from the sheet as desired. In this instance, due to the force of gravity on the mass of abrasive particles contained in the hopper bearing on those adjacent th outlet, the particles are moved upwardly toward the sheet by the mechanical force thus exerted. Coupled with this, an electrostatic field of a relatively lower voltage or difference of potential may be employed.

Owing to the fact that the structure of Figure 3 involves the provision of means for obtaining a nicety of control and balance which might readily become out of control in use, I have provided the forms of the invention shown in Figures 11 and 12.

In the structure of these figures it is possible to control to a nicety the mechanical and electrical forces exerted to obtain the desired result, namely, orientation of the particle on the adhesively coated sheet with its major axis perpendicular to the sheet.

Referring now to Figure 11, it will be observed that a flight of paper follows the path similar to that shown in Figure 6, the paper being indicated at 97a, and being coated on one side from a tank 96a and supplied to the coating apparatus with one flight 97a of the paper having its adhesively coated side presented downwardly. Beneath the adhesively coated flight 97a, I provide a conveyor 98a on which grit particles are deposited from a controlled hopper 98a having

a gate 61a. The conveyor 58a supplies the grit particles in a direction to the left as viewed in Figure 11 to a point below the adhesively coated flight 57a of the paper web.

Beneath the conveyor 58a adjacent to the point of deposit of grit on the sheet, I provide a beater 68a, similar to that shown in Figure 6. The beater and conveyor are mounted on suitable supporting means comprising the arm 64a, and toggle means 66a for adjusting the arm and the conveyor.

Also supported from the arm 64a I provide an electrode 70a, which has a complemental electrode 71a located above the horizontal flight 57a of the paper web, thus the beater acts to raise the grit particles from the conveyor 58a and may be regulated so as to exert a force insufficient for causing the particles to reach the adhesively coated sheet 57a, but when the electrical field is established between the electrodes this field combining its forces with the mechanical force exerted by the beater will serve to cause the particles to be propelled on to the adhesively coated surface and due to the polarisation effect of the electrostatic field to orient the particles with their major axes substantially perpendicular to the adhesively coated sheet.

It will be understood that by proper control of the electrostatic field and the mechanical forces imparted to the particles by the beater 68a that quite as desirable effects can be obtained in the ultimate abrasive article as are obtained in the other forms of the invention already described. Furthermore, this form of the invention permits of the employment of a much lower difference of potential or voltage between electrodes for obtaining the desired result.

Referring now to Figure 12, there is provided a web of paper trained over rolls 6a and coated at 8a by rolls 7a and 8a, this web being so trained over additional rolls as to present an adhesively coated flight 18a with the adhesive presented downward.

Beneath the flight 18a I provide a supporting arm 22a having mounted thereon a conveyor 18a receiving sand from a hopper 29a. The arm 22a may be adjusted by a toggle mechanism indicated at 24a and the conveyor 18a conducts grit from the hopper 29a to the point beneath the flight 18a of the adhesively coated web.

At this point I provide a plurality of nozzles 27a delivering an air blast upwardly through the conveyor 18a, said conveyor preferably being of a screen character permitting the air stream to pass through the conveyor and tend to raise the grit particles into the space between the conveyor and the adhesively coated surface of the flight 18a.

Above the flight 18a I provide an electrode 29a and the air blast nozzles 27a may serve as another electrode supplemental to the electrode 29a.

Thus an electrostatic field may be established between the electrode 29a and the nozzles 27a, but of insufficient force to, operating alone, lift the grit particles and deliver them to the adhesive sheet, but coupled with the agitation of the particles caused by the air blast, the combined forces of the air blast and the electrostatic field serve to deposit, orient and distribute the particles in the desired position on the adhesively coated flight 18a.

If desired, a separate electrode 27b may be added instead of employing the nozzles 27a as electrodes.

I wish to point out that where the expressions "electromagnetic" and "electrostatic" are employed in the specification, I refer to the employment as well of a permanent magnet or some other form of static charge or magnetic charge which will perform the function.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is:

The method of coating a backing with a pulverulent material of elongated dimensions which includes as its steps forming said material from a bulk source of supply into a preliminarily distributed layer arranged in a plane in substantial parallelism to the backing and the propulsion of the pulverulent material from said layer under relatively high velocity onto one surface of the backing in a direction counter to the force of gravity for effecting an orientation of said material with its elongated dimension substantially erect in respect of said backing surface.

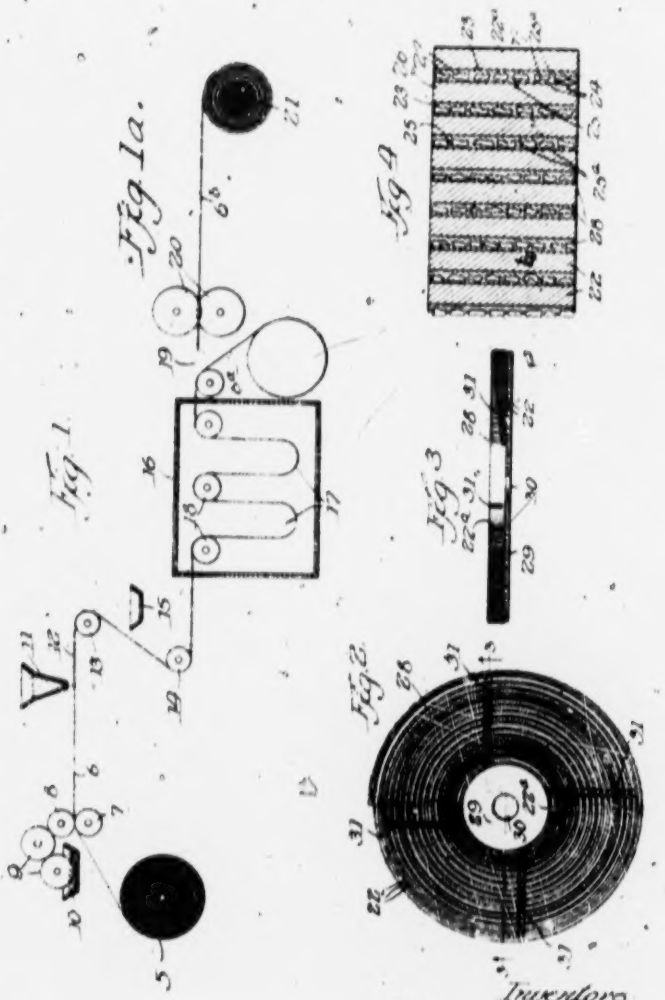
RICHARD PAUL CARLTON.

[Vol. 800]

March 20, 1945. R. P. CARLTON ET AL 2,371,605

COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 1



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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 2

Fig 5.

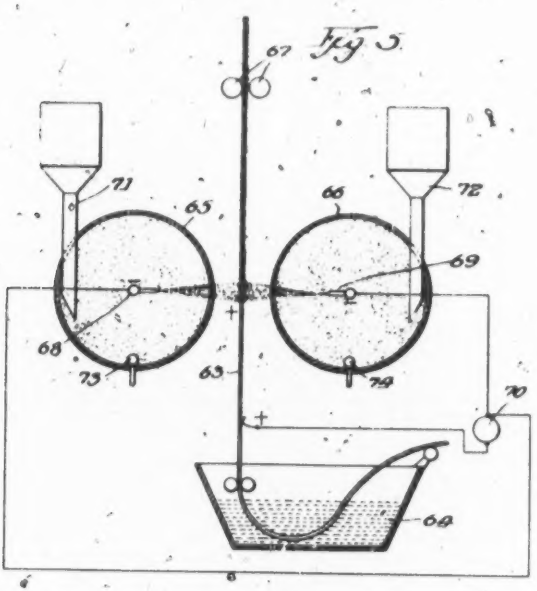


Fig. 6.

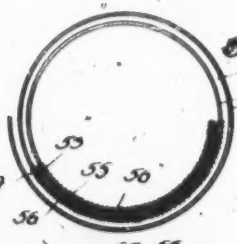
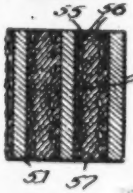


Fig 7



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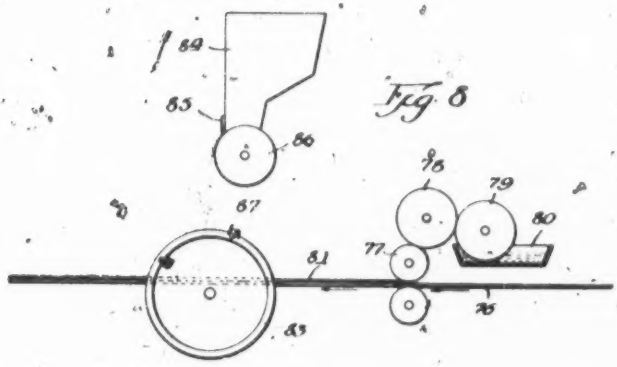
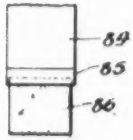
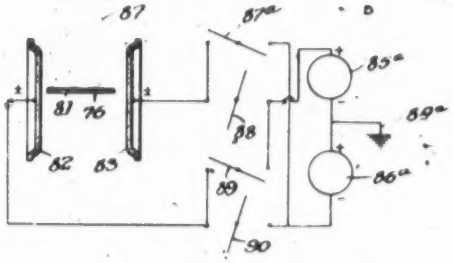
COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 3







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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

Original Filed June 1, 1933 5 Sheets-Sheet 4

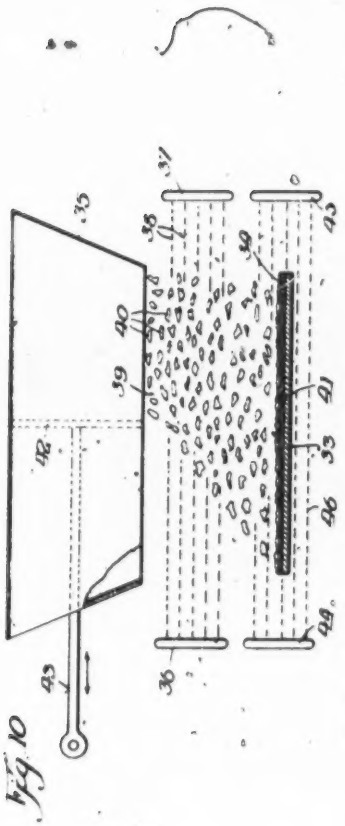

Fig. 10

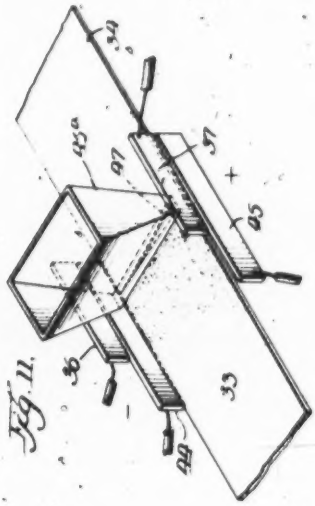

Fig. 11.

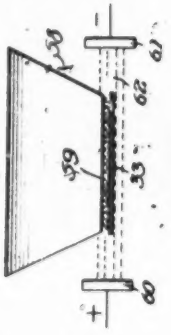

Fig. 16

Fig. 13

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COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

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Fig. 14

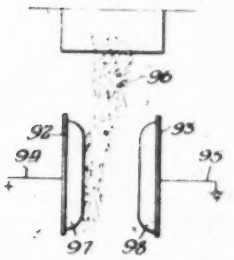


Fig. 15

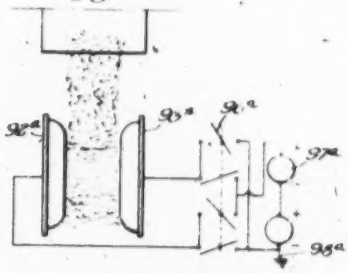


Fig. 16.

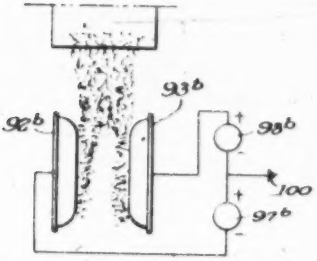


Fig. 17.

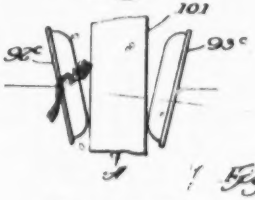
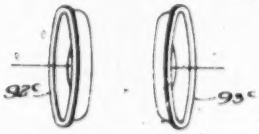


Fig. 17a



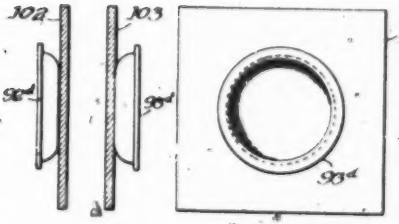
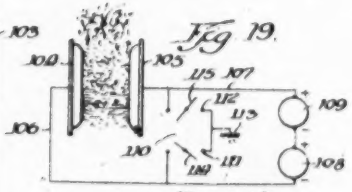


Fig. 18.

Fig. 18a.

Fig. 19.



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Patented Mar. 20, 1945

2,371,605

UNITED STATES PATENT OFFICE

2,371,605

COATING, PARTICULARLY FOR MANUFACTURE OF ABRASIVES

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Original application June 1, 1933, Serial No. 673,886. Divided and this application March 31, 1933, Serial No. 290,550

8 Claims. (Cl. 117—17)

This application is a division of our copending application, Serial No. 673,886, filed June 1, 1933.

This invention relates broadly to coating and coating materials especially in sheet form, such as in the manufacture of abrasives, and the present invention among other things finds utility in one of its phases in the manufacture of abrasive wheels or discs, and while the invention in one of its forms is illustrated as adapted for coating and forming an abrasive disc, it will be understood that certain other phases of the invention are of quite general application and may be adapted for other purposes, such, for example, as a method of coating roofing material with pulverulent mineral.

This invention, as will hereinafter appear, finds especial utility in the production of grinding discs wherein the abrading surface is on a side thereof rather than on the periphery; and the invention also finds utility in coating roofing material so that particles of mineral deposited thereon are caused to lie flat, that is to say, with their major dimensions substantially parallel with the surface of the backing.

The customary procedure generally resorted to in the manufacture of abrasive wheels, discs and the like generally includes the mixing of an abrasive grit, such as aluminum oxide, silicon carbide or emery, with a suitable bonding material and then placing the mixture in a mold. The final setting up of the bonding material is then effected by curing at a sufficient temperature to cause the bond to flow and take a firm grip of the abrasive grit. Several different forms of the adhesive or bonding material are used, the more common being that known as a vitrified or ceramic bond. In making such a wheel it is necessary to fire the wheel, that is to say, subject the mixture of bonding material and grit to a sufficiently high temperature to cause the bonding material to flow and thus, in effect, form a porcelain bond between the various particles of grit. Obviously, such a wheel or disc is inflexible, broadly, and will not stand shock or sudden thrusts.

It has been proposed to employ as substitute bonds for the vitrified or ceramic bond, materials such as rubber, shellac, sodium silicate, natural and synthetic resins and the like.

In producing an abrasive disc or wheel, aside from the problems of choice of bond, there is also the necessity of controlling the ratio of bonding material to abrasive material, and it is also highly desirable that, in certain forms of the abrasive wheel or disc structure, more or less porosity or voids in the wheel acting as clearances for the material being abraded be provided so that fast and continuous cutting, together with reduction in temperature of the wheel when engaging the work, should be attained. In obtaining these desiderata it is found that the porosity of the wheel in the case of a molded structure tends to weaken the disc or wheel and, due to the porosity, the structure does not have sufficient bond to firmly anchor the grit therein.

The principal objects and advantages of the present invention reside in the provision of an improved method of manufacturing an abrasive wheel, disc or the like having characteristics in its structure which increase the cutting ability, strength and durability of the device; the provision of an improved method of manufacturing an abrasive article such as a wheel or disc for abrading purposes, in which the cost of manufacture is considerably reduced, with the attendant accomplishment of the desired control of ratio or bond, that is to say, adhesive, to the mineral or grit, and to provide such an improved method in which the same may be carried out as a substantially continuous process, thus simplifying the manufacture and reducing the ultimate costs; the provision of an improved method of manufacturing abrasive wheels and discs in which a fabric such as paper, cloth or the like may be employed as a carrier for the bond and grit and in which the ultimate size of the abrading wheel or disc may be determined easily and by a substantially continuous method; the provision of an improved form of abrading wheel or disc wherein a controlled porosity of the structure is obtained and wherein the ratio of adhesive material to grit is substantially uniform throughout the entire wheel or disc; the provision of an improved abrasive article such as a wheel or disc wherein the grit particles are oriented so that their most effective cutting edges are presented at the abrading surface and thus are brought into contact with the work more efficiently; the provision of an improved method of manufacturing abrasive discs, wheels and the like in which the production of the abrasive article may be carried out on existing sandpaper type of equipment, with the subsequent convenience of shortening the required time for producing various sizes of abrasive wheels and discs.

A further advantage of this invention resides in that, as distinguished from the molding process of making abrasive discs and wheels, which requires that the abrasive grit and bonding material be mixed in the proper ratio, then molded then heated, and therefore requiring each sepa-

[fol. 806]

rate size of wheel or batch to be handled completely individually from the beginning to the end of the entire fabrication process, the present invention permits of the carrying out of a substantially continuous process similar to the manufacture of sandpaper and that continuous lengths of the material may be stored in drums or rolls from which the desired width of strip may be cut which is to determine the ultimate thickness of the wheel, it being assured at all times that the ratio of abrasive material to bonding material will remain substantially uniform throughout the particular wheel or disc structure which it is desired to form.

The present invention also permits of the manufacture of the basic abrasive material on standard sandpaper equipment and that this material may, after having been prepared, be preserved in stabilized form for use in manufacturing wheels as desired, the process and the article thus permitting of the production of one or more wheels of a desired size and texture, that is to say, grit size or number, at less cost and more conveniently than is possible with the previous processes known to us.

It has also been suggested in the prior art that abrasive discs and wheels be made up of a series of superposed discs of ordinary sandpaper, emery paper or cloth or the like glued together and subjected to pressure and heat, but in such prior process and article made therefrom known to me considerable waste occurs in that the discs must be cut from a standard made piece of sandpaper, and the portion thus made and not used must be thrown away. The present invention distinguishes from such process in that there is substantially no waste of abrasive material which is attendant upon any dieing out process, hitherto suggested.

The present invention also has as one of its objects the provision of an improved method of producing a flexible abrasive article and the resultant article so that, as desired, the manufacturer may produce an abrasive article of the desired degree of flexibility, and, at the same time, have a substantially homogeneous structure with a substantially continuous abrading surface.

The present invention also contemplates the employment therein and for the production of the abrasive article of a new process of orienting the abrasive grains so that their sharper points will be presented at the abrading surface. In ordinary sandpaper the abrasive grains are deposited on the adhesive coated sheet by gravity and as a result lie in haphazard fashion in the adhesive.

In the present invention it is desirable that the abrasive grains be oriented so as to present the longitudinal axes of the individual particles in a position substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof so that when the abrasive article is formed from a sheet of abrasive material made according to this invention, to form an abrasive disc, the sharper points of the grains will be presented at the margins at each of the convolutions of the disc.

This orientation of the grains may be conveniently accomplished by the action of an electrical field, and it is therefore one of the further objects of this invention to provide an improved method of and apparatus for subjecting the abrasive grains to the action of an electrical field for the purpose of attaining the desired orientation of such particles; the invention further has as one of its objects the improved method of and apparatus for subjecting the abrasive grains during the flight by gravity to the sheet to the effect of an electrical field, preferably of the electrostatic type, for aligning the particles with the lines of force of the field, which for convenience be substantially parallel with the surface of the abrasive sheet, thus orienting the grains in the proper desired manner as they are deposited thereon.

This invention also contemplates the improved method of incorporating the grit particles in an adhesive in plastic form, and while the same is deposited together with the grit on a flexible backing subjecting the incorporated grit and adhesive to the action of an electrical field for aligning the particles and orienting the same in the desired manner.

The method involved in the present invention may be carried out in a number of alternative steps, depending upon the form and characteristics as to flexibility and denseness which it is desired to impart to the finished article.

A preferred method of producing the abrasive article of this invention includes the selection of a fabric, preferably paper, of a desired and suitable weight, coating this paper with a bonding material and a suitable grit. For our purposes, we prefer to employ a waterproof bond, and, for example, this may be any of the bonds described and claimed in the patents to Okie 1,868,627, 1,865,028, 1,635,801, Carlton 1,775,631, 1,736,564.

This paper thus coated with a waterproof bond and a suitable grit may be of the same characteristics as the waterproof sandpaper now known to the trade as "Wetordry."

The coated fabric, preferably paper, having the grit contained in the adhesive layer may be provided with a light or heavy sizing coat, depending on the use to which the material is to be applied, though in most instances a sizing coat may be omitted.

After the bond and adhesive or grit have been applied, the material is then festooned for a sufficient period of time to dry or partially solidify the adhesive. It is preferable that the adhesive be not set to its final condition at this time but to aid in handling the adhesive should be dried to a degree which will prevent accidental displacement of the grit.

The abrasive sheet thus formed may be rolled into what are known as jumbo rolls and may be stored until required for slitting into suitable widths. When it is desired to complete a grinding disc with this material the same may be slit to any desired width which is to be the depth of the disc or wheel and then wound into rolls of the required diameter. Owing to the fact that the adhesive material is not entirely set when the sheet is wound into a roll, the disc or wheel thus formed may be placed in an oven for further drying and for completely setting up the bond.

By regulating the tension of the strip of abrasive material as it is wound into disc-like form the compactness and resultant flexibility of the final product may be desirably controlled.

It will be understood, of course, that the resultant flexibility of the article is more or less dependent upon the type of adhesive employed, and that by controlling the flexibility of the adhesive and the tension upon winding the ultimate flexibility of the article may be regulated. As to the waterproof qualities of the article, excellent results may be obtained by employing any of the binders disclosed in the patents mentioned herein.

In the actual finished disc material thus produced particularly where the strip of adhesive material is relatively loosely wound to form a disc, the convolutions thereof will afford clearance spaces, though they may at numerous points be adhering together by virtue of the adjacent layers of the adhesive. In the actual finished article we thus are able to produce an abrading surface which has sufficient flexibility as to binder and composite to facilitate surface sanding, as it is called, and also to facilitate clearing of the wheel when it is in use.

We have found that in some cases of flexible discs or wheels it may be desirable to cement the layers or convolutions of the disc together, but this is not the preferred practice for the normal surface sanding job, and we have found that for such purposes merely winding the strip of material upon itself and then attaching it to a suitable backing, preferably flexible in nature, will produce a grinding wheel or disc giving a desirable flexibility and an efficient cutting surface.

In instances where it is desired to make a solid wheel, that is, a relatively inflexible wheel or disc, it may be desirable to cement the laminations, layers or convolutions, as they may be termed, and this may be accomplished by interposing a sizing coat as the strip is wound into the disc form. It also may be desirable in some instances to apply the sizing material in a relatively heavy coating and to subject the article to heat for causing the coating to flow, and thus relatively intimately connect adjacent layers of the abrasive material.

This operation may also be accomplished when the disc is wound by immersing the same in a bath of adhesive size to permit the adhesive material to flow of capillary action between the laminations or convolutions of the disc.

One of the important factors which effect flexibility when the disc is not of the solid type is the degree of tightness of winding, and thus by relatively loosely winding the strip of adhesive material it is possible ultimately to obtain a very flexible abrasive disc.

It is important in the production of a grinding or polishing disc or wheel of the character herein disclosed that the ratio of mineral grit to adhesive be controlled to produce the most desirable coating results and also that the uniformity of this ratio throughout the disc be maintained. By the abrasive article of this invention and the method of manufacturing the same, we are enabled to attain a high degree of efficiency in cutting operations of the disc and to give to the abrasive article a substantially uniform effective abrasive surface throughout, so that as the same becomes worn in service it yet renders the same efficient cutting and/or abrading or polishing functions.

It will be understood, of course that dependent upon the desired characteristics of the finished product, we may employ fine, medium or coarse grits and that, correspondingly, the thickness of paper or other fabric employed and the ratio of adhesive to grit or abrasive particles must be controlled in each instance to the desired degree. In certain instances we applied the adhesive and abrasive coatings to both sides of the backing.

In selecting an adhesive material, we have obtained excellent results with adhesives formed as composite materials from Bakelite, that is, phenol and formaldehyde and other synthetic resin binders, rubber, shellac and the like, it being understood that these materials may be made into a liquid adhesive and can be further molded or softened by subsequent flowing under heat in such manner that a thorough setting or curing of the adhesive is accomplished without detracting from the flexibility thereof.

One example of an adhesive which is suitable for our purpose is that substantially according to the following formula:

	Parts
Bakelite resin	4
Thinner (denatured alcohol)	1

This composition is agitated very thoroughly until a creamy fluid possessing some tackiness is produced. This adhesive is then applied to the sheet which then receives the abrasive material.

In the case of a Bakelite resinous material, the adhesive is dried after having received the mineral either on the racks or festoons or at some other point in the production of the abrasive strip, and we prefer to employ temperatures ranging from normal atmospheric room temperature to approximately 140 degrees Fahrenheit, depending on the length of time of drying. In this drying operation the temperature is maintained at such a point that the thinner or solvent only will be driven off and thus no appreciable hardening or solidifying reaction takes place in the resin at this time. When the strips are coated with this material together with a binder, heat treated as set out above and then wound into discs or wheels, they may be further subjected to heat which causes a flowing of the resinous binder and thus sufficiently unites the several convolutions or laminations of the wheel. Of course, if it is desired to make a substantially rigid wheel in this manner, same may be tightly wound and also subjected to pressure as well as heat subsequently.

When employing a synthetic resinous material such as a Bakelite resin, the same is thinned with a suitable thinner and coated on the sheet in the same manner as that employed in conventionally forming sandpaper. The grit is then applied as quickly after the binder application as may be practicable. The thinners are evaporated at normal temperatures, and the bond thereupon solidifies to the consistency of a varnish partially dried but tack free.

The abrasive article in this condition may then be stored in large rolls and cut or slit into ribbon disc portions as required.

In order to insure flexibility of the abrasive article during handling, it is preferred that the rolls be stored in a humid atmosphere, so that the article will be possessed of flexibility during the heating operation.

After the abrasive material is cut and formed into ribbon discs, the bond may be toughened by further heat treatment at, say, 180 to 185 degrees Fahrenheit for approximately fifteen minutes, which produces a flexible consistency and is suitable for some purposes, or, we may employ temperatures ranging from 250 to 300 degrees Fahrenheit for a period of time of from fifteen minutes to one hour to produce a relatively hard bond in which there is substantially no flexibility in the binder coat itself. Where a flexible binding coat is desired, a proper regulation of the temperatures and employment of suitable modifiers in the Bakelite resin will give satisfactory results.

It will be understood that the preference to storing the abrasive in large rolls, jumbo rolls, as they are called, is that sometimes it is difficult to synchronise the heating operation with the

drying festoons, and for some purposes it is preferred that the abrasive sheet as it is formed be placed in jumbo rolls so that it may be slit to the desired widths as required.

In connection with the foregoing formula we have secured a flexible abrasive strip to be wound into a disc or wheel shape by employing a Bakelite material which does not produce a complete reaction to rigidity or by keeping the temperature below 212° F. and reducing the time of heat treatment.

For the purposes of this invention we prefer to employ a flexible binding material on the flexible backing, but it is to be understood that a satisfactory flexible wheel or disc may be produced employing a relatively less flexible binder by keeping the layers or laminations of the wheel separated.

We have made satisfactory abrasive wheels or discs by employing an adhesive of the varnish type such as is disclosed in the patents to Okie hereinabove referred to, and we have also employed as a binder the material disclosed in the application of Carlton and Oakes, S. N. 660,319.

Where rubber, shellac or synthetic resins other than Bakelite are employed, we also prefer to heat treat the same in the final setting or, if necessary, after first applying the binder to the strip which is to be later wound into the disc form. With rubber, sulphur is added in desired amount to the adhesive material so that the vulcanization of the binder takes place in the heating step.

Under some circumstances, in order to prevent starving of the bond between the grit and the sheet, it is desirable to apply sizing coat to the back of the sheet, and this may be done during the winding of the sheet or after the original process of making the sheet simultaneously with the application of the adhesive and grit.

The outstanding advantages of the present invention, particularly where the same is wound into a roll to form a disc or wheel, reside in that we are enabled to produce a laminated abrasive structure in which the abrading surface presents a more definite and more uniform porosity due to the laminations and due to the spot contacting of the adhesive on one layer with the adjacent layer, and thus producing a greater proportion of voids than is possible or obtainable where abrasive grit and a bond are molded even where equal ratios of bond to grit are employed. Our invention also produces a laminated abrasive structure having an increased strength due to the incorporation therein of the coated backing of fabric such as paper or cloth, which adds to the strength of the entire wheel making the same less brittle and more flexible and permitting of thinner wheels to be prepared than by any other prior method known to us.

Another distinct advantage of our invention resides in the fact that the mineral grits, owing to their elongated nature, may be oriented on the abrading device so that their sharp points are presented at the abrading surface. For some purposes it is desirable to deposit the abrasive grit by an electrical field or other electrical action, such as by an electrostatic field, in such a manner that the grits will become oriented with their major axes parallel to the surface of the sheet and perpendicular to the abrading surface, particularly where the grits are placed so that their major axes are perpendicular to the margins of the strip from which the wheel is wound. We shall describe such a process of deposition of the grits more fully hereinafter.

It will be understood, of course, that after the abrasive strip has been wound to the desired diameter and with the desired degree of tightness, a suitable disc backing may be affixed by a waterproof binder if desired on one surface of the resultant abrasive disc so that the disc may be mounted on a suitable shaft for imparting rotation thereto.

The several methods which may be employed in the manufacture of the abrasive article itself are illustrated in the accompanying drawings, in which—

Figure 1 is a schematic view of an apparatus which may be employed for producing the abrasive article of this invention.

Figure 1a is a schematic view of a slitting and winding apparatus which may be used with the apparatus shown in Figure 1.

Figure 2 is a plan view of an abrasive disc made according to this invention.

Figure 3 is a transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 4 is an enlarged transverse sectional view taken on the line 3—3 of Figure 2 looking in the direction indicated by the arrows.

Figure 5 is a schematic view of apparatus for coating one or both sides of the abrasive article.

Figures 6 and 7 are fragmentary sectional views of an alternative form of an abrasive article made according to this invention.

Figure 8 is a schematic view of an alternative form of apparatus for securing orientation of the abrasive particles.

Figure 9 is a view showing the apparatus of Figure 8 from another aspect.

Figure 10 is an elevational schematic view illustrating alternative apparatus for carrying out the step of orientation of the abrasive particles.

Figure 11 is a perspective view of an alternative form of apparatus of this invention.

Figure 12 is an elevational view of a still further modified form of the invention.

Figure 13 is an enlarged sectional view of a sheet illustrating the alignment of the abrasive grains thereon.

Figures 14, 15, 16, 17, 17a, 18, 18a and 19 are all diagrammatic views of alternative forms of the invention shown in Figures 8 and 9.

Referring now more particularly to the drawings, and first to Figure 1, there is shown a roll of fabric such as paper or cloth 5, from which the web 6 is unwound over an idler roller 7, to receive from a coating roll 8 a layer of the adhesive material delivered by the series of feed rolls 9 from a tank 10. The web 6 is fed beneath a hopper 11 from which is supplied a quantity of comminuted abrasive material 12 by gravity, which may be suitably regulated in any desired manner to determine the thickness of the grit layer. The positioning of the abrasive material may be controlled at this point by the use of electrical orienting apparatus as shown in Figure 8 and hereafter more fully described. The sheet or web 6 is then trained over a roll 13 and reflexively bent upon itself by a roll 14, some of the grit in excess of that desired being removed by falling by gravity into a container 15. The web 6 with the layer of grit secured thereto by an adhesive, waterproof if desired, is then fed into a drying room or oven 16, and arranged in festoons 17 by the provision of rolls 18 in said drying room.

The temperature of the drying room is maintained at a degree which will only partially set

the adhesive sufficiently to permit handling of the abrasive coated strip or sheet indicated at 6a as it leaves the drying room. At this point Figure 1 shows the sheet as broken, indicated at 6b, inasmuch as it may be desired to store the resultant product at this point before continuing the same to the slitting apparatus. However, if it is desired to have a continuous making process, then the sheet or web is supplied to slitting apparatus represented by the cutting knives 20, as shown in Figure 1a. These knives may be arranged at any convenient distance apart, depending on the width or thickness of the strip to be cut and ultimately wound into the abrasive disc.

From the slitting apparatus the several resultant strips of abrasive sheet material may be fed to a mandrel 21, on which they may be wound into the final abrasive disc elements producing the articles such as shown in Figures 2, 3 and 4.

It will be understood that while the strip shown at 6b in Figures 1 and 1a is wound with the abrasive coated side outwardly, thus leaving an outer abrasive coated surface exposed at the last convolution, the disc may be as readily wound in the opposite direction so that the abrasive coated surface of each lamination will be presented inwardly. Inasmuch as these discs are intended to grind on one of their side faces, and as a substantially continuous abrasive coated surface is thus afforded, the discs may be wound either way desired.

It is also to be understood that by placing the strip 6b under more or less tension as desired, a tighter or looser wound disc may be obtained.

When the abrasive material is deposited by gravity as shown in Figure 1, it will be understood that the abrasive grains will be largely lying haphazard on the abrasive surface, though a large number of them will be oriented by the contact of the freshly coated surface with the roll 14, so that when the strip 6b is wound into a roll to form the disc the grains will be knocked down in such a manner that their sharper points will, as the disc is employed in grinding or polishing the surface, be brought against the surface of the work. However, to insure that the majority of the grits will be so oriented, we have provided methods and apparatus for so orienting the grains which will be described more fully hereinafter.

Figures 2, 3 and 4 illustrate a disc made according to this invention, wherein the disc is composed of a plurality of convolutions 32 of abrasive coated material affording a laminated abrasive structure. The laminations are held together by the adhesive material establishing contact on one convolution with the back surface of the adjacent convolution so that a structure somewhat similar to Figure 4 will be obtained, the innermost convolution 32c having its coating 28 of adhesive material contacting at a plurality of points, indicated at 34—34 with the back surface 29 of the immediately adjacent convolution 32. Thus the abrasive grains indicated at 27 in the layer of adhesive 28 are substantially embedded therein with their major axes and thus their sharper cutting points presented toward the margins of the laminations. In this way a substantially continuous abrading surface indicated at 28 on the surface of the disc is thus provided. It will be understood that care must be exercised that the proper weight of paper with regard to abrasive and adhesive be selected.

The disc-like structure thus provided may be secured to a flexible backing 29 of paper or cloth or other suitable material having an axial opening 30 by which the same may be attached to the rotating shaft of a grinding machine.

It will be understood that the backing 29 should be cemented to the disc by a flexible waterproof adhesive similar to that employed in the disc itself, or, if desired for some purposes, the backing 29 may be of a rigid material and the disc likewise cemented thereto.

In Figure 4, it will be understood, of course, that the thicknesses of the convolutions and layers of grit and adhesive have been greatly exaggerated in size, although it is conceivable that one might produce an abrasive article having convolutions whose thicknesses are as great as those shown in Figure 4. However, in the ordinary form of the invention for employment in standard surface grinding the disc is made up of a sheet not substantially greater in thickness than a sheet of ordinary sandpaper, thus lending to the final product a desired degree of flexibility.

It will be observed that in some instances it may be desirable to provide grooves in the abrading surface 28, these grooves being shown at 31 in Figures 2 and 3. It will also be noted that the grooves 31 are preferably of greater depths at their inner ends toward the axis of the disc than at their outer ends adjacent to the periphery of the disc. These grooves may be formed in the disc after the fabrication of the same inasmuch as forming the grooves in the strip prior to finally winding would require considerable care in aligning the notches in each convolution from which these grooves are formed.

The disc thus formed contains a number of voids which are afforded by virtue of the grit particles themselves holding the laminations apart and by the vacant places indicated at 28e where the glue or other adhesive does not completely fill the spaces between the convolutions. Thus the abrasive article quickly cleans itself as it works and clogging or loading of the article is practically impossible.

We have found that a satisfactory grinding and polishing wheel may be constructed by methods disclosed herein, and in one form of the invention, which is illustrated in Figures 6 and 7, we apply a coating of adhesive material containing an abrasive to both sides of the strip forming the flexible abrasive article. This coating operation may be accomplished by the apparatus shown in Figure 5.

After making a double coated strip, it is then wound loosely into a configuration substantially like that shown in Figures 6 and 7. The thus wound material is then thoroughly cured and dried. After curing, the disc-like structure then afforded is cemented to the cloth backing in such a manner as to preserve the open or spaced convoluted structure as shown. The polishing compound, which may be according to the formula appearing below, is then forced into the spaces between the layers and when completely filled with polish the disc is then aligned to set for sufficient time to solidify the polish base. The drying time, we find to give best results by subjecting the article to a drying temperature for approximately forty-eight hours.

A satisfactory formula which we have em-

[fol. 810]

played for the purpose of compounding the polishing material may be as follows:

	Grams
Nitro base thinned to 50% solids	200
Dibutyl phthalate	4.0
600 silicon carbide	46.0
Tripoli	138.0
Borax	16.0
Ethalin	4.0

From the foregoing it will be observed that we produce a convoluted structure indicated generally at 36, composed of the laminations of the convolutions 31 of suitable fabric coated on both sides as indicated at 33 and 34 with adhesive 35 containing the comminuted abrasive material 36.

It will be noted that sufficient space is afforded between the layers 31 particularly as shown in Figure 7 to permit of the introduction of a comminuted polishing material indicated at 37. Thus the finished article possesses both grinding and polishing properties.

It will be understood that it is highly desirable that the comminuted abrasive material be disposed on the strip or sheet in such manner that the individual grits will have their major axes preferably lying parallel with the surface of the sheet, and, where the sheet is to be wound later to form a disc which marginally exposes an edge of the sheet for forming the abrasive surface, that the grits be perpendicular or substantially perpendicular to the longitudinal margins of the sheet.

While orientation of the grits with their major axes parallel with the surface of the sheet and substantially perpendicular to the edges thereof, may be more or less accomplished in simple gravity deposition of the grits on the adhesive coated sheet, a positive orientation of the individual grains may be accomplished by electrical action, that is to say, the grits may be deposited on the sheet in the presence of an electrical field, for example electrostatic, or if the grit particles are of a magnetically responsive nature then in the presence of an electro-magnetic field. Grits deposited in the presence of such an electrical field will be caused to align themselves with the lines of force of the electro-magnetic or electrostatic field as the case may be.

For most abrasive articles an electrostatic field will perform the function inasmuch as most of the grit particles commonly employed in the abrasive arts are of a non-magnetic character and are non-conductors and practically all will respond to the force of an electrostatic field.

Referring specifically to Figure 5, we provide a suitable backing for carrier strip 63 which receives coats of adhesive material on both sides thereof from a suitable tank 64, the strip being conducted upwardly between two chambers 65 and 66 and then conducted through edge guide rollers 67.

In the chambers 65 and 66 there are provided electrodes 68 and 69 of preferably negative polarity, the sheet being itself of a conductive nature and connected to the positive side of a source of electric motive force indicated at 70.

The apparatus receives grit from hoppers 71 and 72 which is agitated in the form of clouds within the chambers 65 and 66 by air blasts introduced at the nozzles 73 and 74.

The apparatus shown in Figure 5 is similar to that shown in the patent to Simpson 1,336,300, and serves to illustrate one apparatus for carrying out the double coating simultaneously. This form of the apparatus does not, however, produce orientation of the grit particles with their major axes parallel to the plane of the sheet, and reference will be made hereinafter to forms of the invention including apparatus for this purpose.

It will be understood that the sheet may be coated on both sides by running it twice through either a gravity coating apparatus or any of the apparatus shown in the other figures of the drawings.

As herein pointed out, it is desirable to orient the grit particles so that they will lie with their major axes substantially parallel to the surface to be coated, and they will thus present their sharp points at the edges of the strip as the same becomes worn in use as an abrading disc.

This orientation of the particles uniformly on the sheet is also of utility in the manufacture of mineral coated shingles wherein it is desirable that the particles of mineral, granules or the like, be deposited so that a minimum number of the mineral granules is required to cover a given area of the asphaltum sheet or other material from which the carrier or backing of the shingle is made.

We have illustrated herein a number of ways in which this may be accomplished which are all included in the disclosures of Figures 8 to 12, both inclusive, and Figures 14 to 18, both inclusive, it being understood that these electrical orienting devices are to be used in the general apparatus shown in Figures 1 and 1a at the point indicated by the hopper 11.

With reference first to Figures 8 and 9, we have employed a backing 76, of suitable material which receives a coating on the upper surface of the horizontal flight thereof shown in Figure 8, this coating being applied from a set of adhesive distributing or applying rollers 77, 78 and 79, the latter taking up adhesive from a tank 80. This adhesive layer is indicated at 81 and the backing is then propelled to the left as viewed in Figure 8 between electrodes forming an electrostatic field.

These electrodes, we have found, may conveniently comprise a pair of circular disc-like plates 82 and 83, between which the horizontal flight of paper 76 passes at a desired rate of speed. Other forms of the plate electrodes may be employed, but we have found that this type produces a uniform field and highly satisfactory performance.

Above the flight 76, and at a distance sufficiently remote from the electrodes so as to be substantially unaffected thereby, we provide a hopper 84, which may contain abrasive grains of the desired size. We find that for our apparatus an abrasive grain or pulvule of a silvery character that is somewhat elongated, will give highly desirable results as to orientation, though it will be understood that it is not necessary that this type of pulverulent material be employed in order to attain the results of this invention. Practically all of the grits employed in the abrasive industry today are characterized by having a major and a minor axis so that they become responsive to the action of an electrical field when introduced into the presence of the same.

These grits are deposited by gravity from a hopper 84 having a suitable controlling gate 85 over a distributing roller 86 so that they fall in a substantially continuous stream 87 toward the adhesive surface 81, passing between the elec-

trodes 32 and 33 in their path to the adhesive surface.

We have discovered that a static electrical field solely, that is to say, without outside influence, mechanical or otherwise, acting upon the grit particles, tends to deflect them toward one of the plates, and in order to correct this and produce a more uniform distribution and yet obtain orientation, we employ a pole changer, diagrammatically illustrated in Figure 9, through which the two electrodes 32 and 33 are connected to the source of electrical difference of potential.

A source of electromotive force, preferably of relatively high voltage, is provided. The voltage employed in one arrangement of the electrodes was about 105 kilovolts and in employing this voltage the plates or electrodes were spaced about 5.5 inches apart in air. This arrangement served to maintain a constant electrical potential gradient of approximately 19 kilovolts per inch between the electrodes.

In correcting for uneven distribution, the electrical center of the source of difference of potential is grounded as indicated at 84a in Figure 9, and the source composed of two units 85a and 86a is so connected through pole changing switches 87a, 88, 89 and 90 that the relative polarity of the two plates 32 and 33 forming the electrostatic field was changed at a desired frequency.

We have found that, for our purposes, with the plates spaced between 5 and 6 inches apart in air, the best results are obtained by the use of electrical potential gradients of the range of from 17 to 20 k. v. per inch. We also find that where reversal of polarity is resorted to, as in the disclosure in Figure 9, the optimum of frequency of polarity change or reversal should be in the vicinity of two cycles per second. However, we have found that ranges of from one cycle per second to four cycles per second produce satisfactory results and that little change was noted in thereby producing satisfactory distribution and orientation of grit particles on the sheet.

It will be understood that the foregoing disclosure of values as to voltages, rates of polarity change, and size of and distance between the plates is all subject to variation to suit the particular conditions and results to be attained thereby.

We have also found that with different types of abrasive grains different results were obtained. For example, with silicon carbide in some arrangements of the plates compensation had to be made for difficulty encountered due to the high conductivity of silicon carbide, where as with certain other grit particles these difficulties were not found present, such, for example, as in the use of flint.

From the foregoing it will be understood that the electrostatic field established either constantly or intermittently together with reversal of polarity between the plates 32 and 33 affects the grit particles, as they enter the electrical field, to bring them into axial alignment with the lines of force of this field. No appreciable difficulty is found to exist by the presence of the backing material 76 in the field, which would ordinarily be assumed to occur due to the setting up of extraneous electrostatic fields between the two electrodes and the backing itself, this difficulty being eliminated by the form of the electrodes, so that the major value and resultant force of the electrical field is retained.

In the more convenient form of the invention shown in Figure 9, successful results will be obtained by employing disc-like electrodes 32 and 33 of a diameter of about 8 inches, and with the opposed faces of the electrodes substantially parallel to each other.

A further form of apparatus which we may employ for carrying out this method of deposition is illustrated in Figure 10 wherein the strip, sheet or web of Figure 1 is indicated at 33, the one side of said sheet being provided with a layer 34 of adhesive material, preferably waterproof in its characteristics, though, as will be obvious, this layer of adhesive may be of the ordinary blue bond type employed in the sandpaper industry for non-waterproof abrasive articles.

The sheet 33 is caused to travel in a substantially horizontal plane below a hopper 38 and between the electrodes 36 and 37 of an electrical field, the electrodes 36 and 37 being connected to an appropriate source of electrical potential of the required value. In actual practice what are known as high voltages may be required, though it will be understood that the difference of potential to be employed is subject to variation a desired for accomplishing the ultimate desired action.

For the purpose of the present disclosure the electrodes 36 and 37 form part of an electrostatic field, that is to say, a field in which a constant stress is set up but in which relatively small currents flow. Such an electrical field will be established between the electrodes 36 and 37 indicated generally by the lines of force 39. This field is set up between the electrodes 36 and 37 above the sheet 33 and below the hopper 38, and the field strength is regulated to such an extent as to act upon the abrasive particles as they are fed from the hopper 38.

The abrasive particles are shown as a cloud 39 but some of them are shown enlarged at 40 depicting the approximate positions which they assume as they fall by gravity through the electrostatic field. It will be understood that should the electrostatic field be of great enough strength, the particles issuing from the right hand end as shown in Figure 10, would be cause to orient themselves with their major axes parallel with the lines of force of the electrostatic field and be projected by that field from one of the electrodes toward the other thereof. Therefore, by regulating the electrostatic field to the desired optimum the particles will be caused merely to flatten out, and while they may, under these circumstances be caused to travel along the lines of force of the field, the force of gravity will tend to overcome their flight toward the oppositely charged electrode and they will fall upon the layer of adhesive, assuming positions substantially as shown in Figure 10, and indicated at 41. This orientation is more uniformly accomplished, however, in the form of the apparatus shown in Figures 8 and 9.

Inasmuch as the particles of abrasive material as they leave the hopper adjacent to the electrode 36, may in a large number of instances never reach the sheet, due to their attraction to the other electrode, we provide a movable partition 42 in the hopper, which may be adjusted transversely of the longitudinal axis of the sheet so that the length of the slot in the bottom of the hopper may be varied to cause the grit particles to issue through only a portion of said slot. A suitable handle properly insulated indicated at 43 may be employed for reciprocating the par-

tition 42 and for adjusting same to the desired position.

In some instances the particles of grit will take on charges which may tend to cause them to induce a charge in the sheet and thus the particles would land on the sheet substantially perpendicular to the plane of said sheet. In order to avoid this as much as possible and to counteract a tendency for the particles to assume positions perpendicular to the sheet, the electrodes 36 and 37 may be supplemented by auxiliary electrodes 44 and 46 which may have a voltage regulated (by means not shown) to exert a sufficient electrostatic field effect or action to prevent the particles from taking undesirable positions just as they strike the glue. If desired, this auxiliary field whose lines of force are indicated at 48, may be extended a desired distance beyond the point of actual deposition so that it will function for a period of time after the sheet has moved beyond the effect of the major electrostatic field.

Inasmuch as the poles or electrodes 36 and 44 and 37 and 46 are of like signs, there will be no tendency to set up extraneous electrostatic fields between these electrodes other than substantially ineffective electrostatic or electro-magnetic fields, as the case may be, due to difference in actual potential of the two fields 36 and 46. In any event, inasmuch as the electrostatic fields employed have their lines of force substantially parallel the effect of any extraneous field set up between the electrodes 36 and 44 and 37 and 46 should be substantially negligible in disturbing the desired deposition and orientation of the particles on the sheet.

An illustration of one arrangement of the electrodes which will set up the desired electrical action is shown in Figure 11 in perspective. Of course in some instances it may be desired to eliminate the secondary electrostatic field 46 and by proper control of the moving partition 42 the desired results may be attained as to ultimate effect of the field on the grit particles.

Figure 11 serves to illustrate a further modified form of the hopper. In this form the hopper is of a general V-shape cross section and the bottom thereof being open is provided with a tapering slot indicated at 47. The slot is of greater dimensions at one end than at the other end so that by proper positioning of the hopper the particles of abrasive acted upon by one of the electrodes and tending to be projected toward the other thereof would be counteracted by the tapering slot in the hopper, thus preventing piling up of the abrasive grit at one margin of the sheet.

It will also be understood that by regulating the height of the hopper 48a from the sheet that different effects may be obtained to the point where the desired orientation and deposition of the grit is attained.

The electrodes 44 and 46 may be employed in Figure 11 as in Figure 10 if that be found necessary under the circumstances.

Referring now to Figure 12, the apparatus here shown discloses a hopper 50 into which the comminuted abrasive material and an adhesive material in plastic form are introduced. The hopper may be suitably heated to maintain the adhesive material in a liquid state so that it will flow from a suitable opening 52 provided in the bottom of the hopper.

As the incorporated grit and adhesive material flow from the hopper on to the sheet 33, the mass is subjected to the forces of an electrostatic field 56 set up between the electrodes 36 and 54 thus orienting the particles of grit contained in the adhesive according to their electrical responsiveness to such a field, that is to say, the grits having major and minor axes, as hereinbefore pointed out, will under the influence of the electrostatic field become aligned with the lines of force 53 shown in Figure 12, while in the glue or other adhesive and thus be carried by the glue or adhesive on to the sheet where they will be deposited with their major axes substantially parallel with the plane of the sheet and substantially perpendicular to the margins thereof.

Figure 13 shows the sheet made according to the methods herein described and it will be observed that in many instances a plurality of layers of grit may be provided and for this reason a sheet such as that shown in Figure 13 is illustrated having two or more layers 41a of grit material and adhesive material deposited thereon.

In order to make clear to those skilled in the art the basic principles involved in employing the electrostatic field for the purposes of the present invention, Figures 14 to 18 have been incorporated in this disclosure showing the various steps in development to obtain the optimum of results in deposition, distribution and orientation of the abrasive particles.

It will be understood that these Figures 14 to 18 all illustrate methods for producing deposition, distribution and orientation, but that some produce better results than others as will appear from the following description.

On reference to Figure 14, a pair of electrodes, preferably in the form of circular discs 82 and 83 are employed, one of these discs being connected to the positive side, such as at 84, of a source of difference of electrical potential and the other disc being connected to the negative side or ground as the case may be.

A relatively high difference of electrical potential was thus impressed on the two plates establishing an electrostatic field between them, into which abrasive particles 86 were introduced, either by gravity as shown in Figure 14, or by any other suitable means, so as to produce a stream of the particles as they enter the electrostatic field established between the plates 82 and 83.

This pair of substantially circular metal plates are made about 8 inches in diameter and provided with curved edges indicated at 87 and 88, thus preventing excessive concentration of the field at the edges of the plates thereby reducing the possibility of sparking between the plates.

These electrode plates were spaced about 5.5 inches apart in air and were connected to a source of electromotive force approximately 105 kilovolts, so that a substantially constant electrical potential range of about 19 kilovolts per inch was maintained between them.

The mineral pulverized material (in one instance grade 90 silicon carbide) was deposited so as to fall in a stream between the two plates 82 and 83.

When either of the plates is grounded, the mineral stream which was originally at ground potential is deflected toward the ungrounded plate, so that if an adhesively coated strip was introduced between the plates 82 and 83, while orientation of the particles transversely of the strip

was attained, yet deposit of mineral would take place in spaces at one edge over that at another edge of the strip.

To overcome this uneven distribution of particles, the plates may be connected to the source of potential through a reversing switch or pole changer which alternately serves to connect each plate to ground and to high potential, in other words, supply an alternating voltage to said plates.

One manner of accomplishing this is disclosed in Figure 15, in which the plates 93a and 96a are connected through a pole changing apparatus 99a to a source of relatively high electrical potential, 97a.

The stream of mineral at low frequencies of reversal of polarity moved from one plate to the other following the reversals of polarity of electrical potential so that over a given period of time (say one electrical cycle) the air space between the electrodes 93a and 96a was substantially uniformly filled with mineral particles.

The source of electrical energy 97a is so arranged in this circuit that one side 96a thereof is connected to ground.

In the case of Figure 16, the plates 93b and 96b are so arranged in the circuit that one of them is connected to one of the sources of difference of potential indicated at 97b and the other to the other source indicated at 98b, the electrical centre of the sources indicated at Figure 16 being grounded as at 100. In this arrangement the main mineral stream becomes divided into two separate streams each of which tended to flow toward one of the plates thereby leaving a low mineral concentration in the space midway between the plates.

From the foregoing Figures 14, 15 and 16 it will be observed that we are enabled by adjustments and variations in the intensity of the electrical field and by its polarity and/or periodicity of change and by other adjustments, to regulate what will happen to the mineral grits as they are introduced into the electrical field. Thus where it is desirable that the grits be more heavily deposited at one portion of the adhesive coating backing than at another portion this can be regulated to a desired degree as required.

Should it be desired to prevent excess deposition of the grit in predetermined areas, then the form of the invention shown in Figure 2 and hereinabove described may be employed. For the purpose of manufacturing abrasive discs as disclosed herein this form of the invention finds utility.

In Figures 17 and 17a, a further alternative arrangement of the electrode plates is disclosed. Figure 17 being a view looking down on the plates, the backing element being indicated at 101 and the plates at 93c and 96c. Figure 17a is a view looking inwardly in the direction indicated by the arrow A.

In Figures 17 and 17a we disclose the electrodes arranged in convergent planes so that some portions of the surfaces of the discs were closer together than other portions, the purpose being to further allow for adjustment in distribution of the grit particles.

The grit particles entering this electrostatic field are subjected to a variation in potential gradient from 17 k. v. per inch to 34 k. v. per inch, or any other variation of the electrical potential gradient, depending upon the voltages employed, size of plates, etc.

The stream of mineral is allowed to fall into the zone whose gradient is about 19 k. v. per inch. There is in such circumstances apparently no tendency for the mineral particles to migrate toward the zone of high gradient, and the general dispersion and orientation of the particles is not materially interfered with and not materially different from that where the plates are substantially parallel, and the potential gradient therefore substantially uniform.

Successful results may be obtained with any of the foregoing arrangements, by the employment of an abrasive grit of a grade 1½ flint, preferably of a splintery nature.

We find that a higher electrical potential gradient may be maintained without disruptive discharge or so-called spark-over with flint, for example, than with other grits such as silicon carbide, inasmuch as in the same air space potential gradient and with the same relative quantity of grit introduced therebetween, the conductivity of silicon carbide, being higher than that of flint, tends to produce an increased tendency to spark-over or brush discharge, as it is sometimes termed, and care must in some cases be exercised to prevent the formation of a conducting path between the plates.

A method of overcoming this difficulty for certain purposes is shown in Figures 18 and 18a, wherein the two plates 93d and 96d were arranged on opposite sides of insulating plates 102 and 103.

While the employment of these plates finds value with certain minerals, there is no marked difference in the action of the electrostatic field with other minerals, and we have found this arrangement of Figures 18 and 18a to be of value in increasing the activity of flint, but of much less perceptible value in increasing the activity of silicon carbide, inasmuch as spark-over or brush discharge sometimes occurs which causes the greater part of the applied voltage to be built up across the insulation.

The observed motion of the particles was substantially the same with or without the insulation, but, as pointed out in the case of some abrasive particles, an increased activity without a resultant brush discharge was observed. The plates also serve as a means to mechanically confine the activity of the particles to the area within the plates.

Referring now more particularly to the form of the invention shown in Figure 19, it will be observed that here may be provided a form of the apparatus wherein the electrode plates are alternately connected to ground. In this form of the invention the plates indicated at 104 and 105 are connected by conductors 106 and 107 to the negative and positive sides, respectively, of sources of electrical difference of potential 108 and 109, that is, sources of potential being connected in series as shown.

A grounding switch is provided indicated generally at 110 and has its terminals 111 and 112 thereof connected to ground as indicated at 113, switching members 114 and 115 serving to alternately connect the conductors 106 and 107 with ground.

It will be seen from the form of the invention disclosed in Figure 19 that by the alternative grounding of the plates 104 and 105, the orienting force exerted on the particle is uniformly maintained by virtue of the maintenance of a constant gradient between the plates. Dispersion of the particles thus uniformly obtained by the use of the switching arrangement prevents the bulk

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of the particles (which, it will be understood, are at ground potential when they pass into the zone of the plates) from being directed more to one plate than to the other.

The form of the invention shown in Figure 15 operates similarly to the form of the invention shown in Figure 9.

Reverting to the form of the invention disclosed in Figures 8 and 9, the structure there employed including a reversal of polarity does not include the insulating plates and these, under ordinary circumstances, are not required.

Under conditions shown in Figure 14 and without the use of insulation on the plates or between them, flint particles dropped into the field whose gradient was 15 k. v. per inch were fairly well oriented on the sheet but the distribution is not entirely uniform.

An increase in gradient from 15 to 17.5 k. v. per inch resulted in the production of a marked increase in the degree of orientation, but as well increased the inequality of distribution.

With abrasive grains of silicon carbide a limitation of the potential gradient was required so as to prevent dielectric breakdown.

The use of insulation on the plates serves to cause the mineral to be more evenly distributed, but it will be understood that some slight amount of orientation must be sacrificed owing to the slight reduction in the potential gradient caused by the employment of the insulating plates.

From the foregoing it will be observed that by adjustment of the electrostatic field value and/or adjustment of the plates with respect to the air space between them and/or their angularity with respect to each other, and/or the periodicity of polarity reversal, we are enabled to produce desired effects in the orientation and distribution of the grit particles on the sheet.

Where the particles are deposited on shingle material for the purpose of roofing shingles and the like, it will be observed that by causing them to lie flat on the adhesively coated sheets, such as an asphaltum adhesive sheet or the like, the employment of a lesser number of particles to cover a given area of the shingles is required.

Having thus described our invention and illustrated its use, what we claim as new and desire to secure by Letters Patent is:

1. The process of coating an adhesively coated backing material with elongated particles with their longer axes substantially in parallelism to the backing which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a suitable surface thereof, and depositing on said adhesive layer a pulverulent abrasive grit of elongated nature in respect to their major axes under the influence of an alternating electrical field whose lines of force at and adjacent said carrier have an orienting effect on the particles to position them substantially parallel said surface thereof.

2. Apparatus for coating adhesive backing material with elongated particles with their longer axes substantially in parallelism to the backing surface including spaced electrodes adapted to be connected to a source of uni-directional electrical difference of potential, means for supplying abrasive particles or the like to the vicinity of said electrodes, a pole changer interposed in the circuit of said electrodes, and means for guiding an adhesive coated backing adjacent said electrodes for positioning the backing otherwise with respect to said electrodes.

3. Apparatus for coating adhesive backing material with elongated particles with their longer axes substantially in parallelism to the backing surface comprising, in combination, spaced electrodes adapted to be connected to a source of alternating electrical difference of potential, means for feeding an adhesive coated backing element between said electrodes to guide the backing within the field between said electrodes and to direct the backing substantially edgewise with respect to the electrodes and means for delivering abrasive particles in a stream toward said backing and between said electrodes.

4. Apparatus of the character described, in combination, spaced electrodes adapted to be connected to a source of electrical difference of potential, means for feeding an adhesive coated backing element between said electrodes to guide the backing substantially edgewise in respect of said electrodes, means for delivering abrasive particles in a stream toward said backing and between the said electrodes, and means for alternately grounding said electrodes.

5. The process of coating which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a suitable surface thereof, and depositing on said adhesive layer roofing granules having elongated dimensions under the influence of an alternating electrical field whose lines of force at and adjacent to said carrier have an orienting effect on the granules to position them substantially parallel to said surface thereof.

6. The process of coating which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a suitable surface thereof, and depositing on said adhesive layer particles of finely divided material having unequal axes under the influence of an alternating electrical field whose lines of force at and adjacent to said carrier have an orienting effect on the particles to position them substantially parallel to said surface thereof.

7. In the process of depositing particles of finely divided material of elongated nature in respect of their major axes upon a surface with their longer axes substantially in parallelism to the surface wherein said particles are subjected to the influence of an electrical field during their deposition, the step which includes reversing the polarity of said field intermittently during the deposition so as to prevent the stream of particles from being thrown out of the desired zone of deposition by the action of said field.

8. Apparatus for coating adhesive backing material with elongated particles with their longer axes substantially in parallelism to the backing surface comprising, in combination, spaced electrodes adapted to be connected to a source of alternating electrical difference of potential, said electrodes being covered with an insulating material minimizing the formation of a conducting path between the electrodes, thereby localizing and minimizing spark-over tendencies, means for feeding an adhesive coated backing element between said electrodes to guide the backing substantially edgewise in respect to said electrodes and means for delivering abrasive particles in a stream toward said backing and between said electrodes.

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MANUFACTURE OF ABRASIVES

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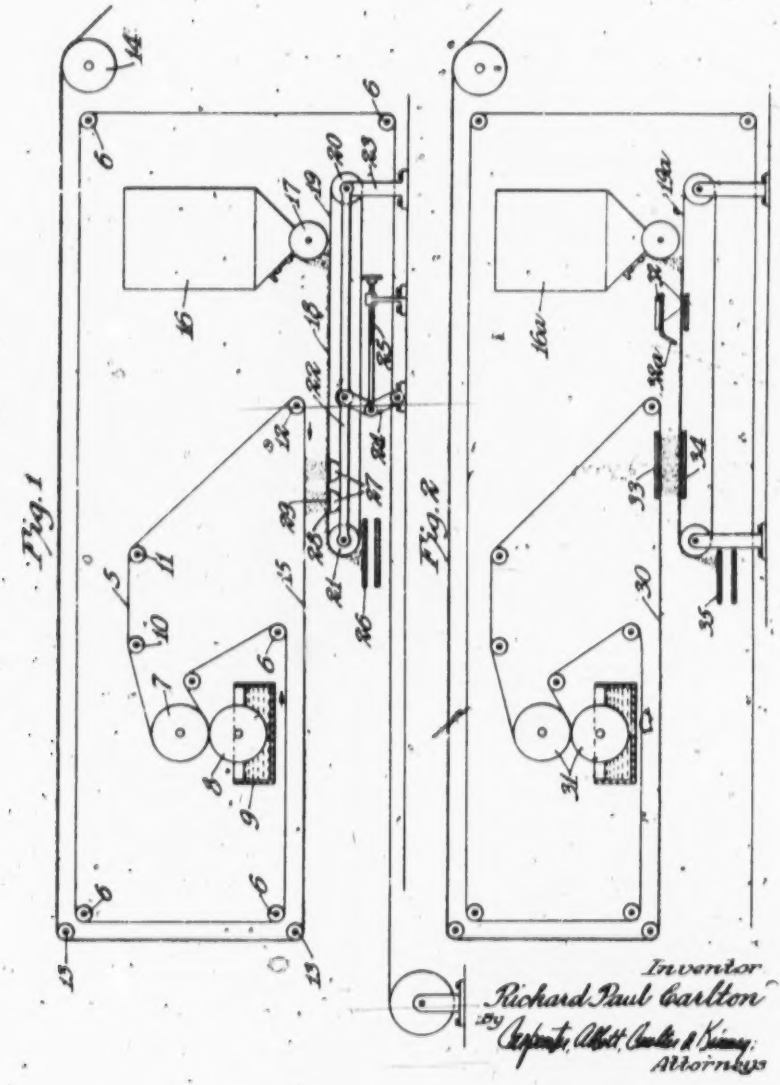

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MANUFACTURE OF ABRASIVES

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Fig. 3

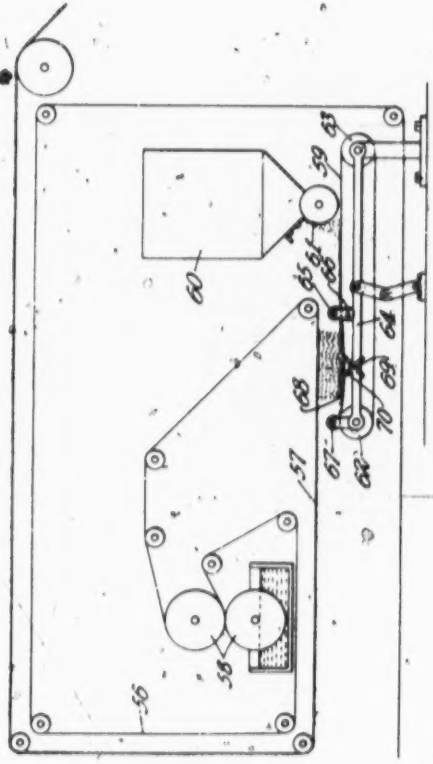

Fig. 4

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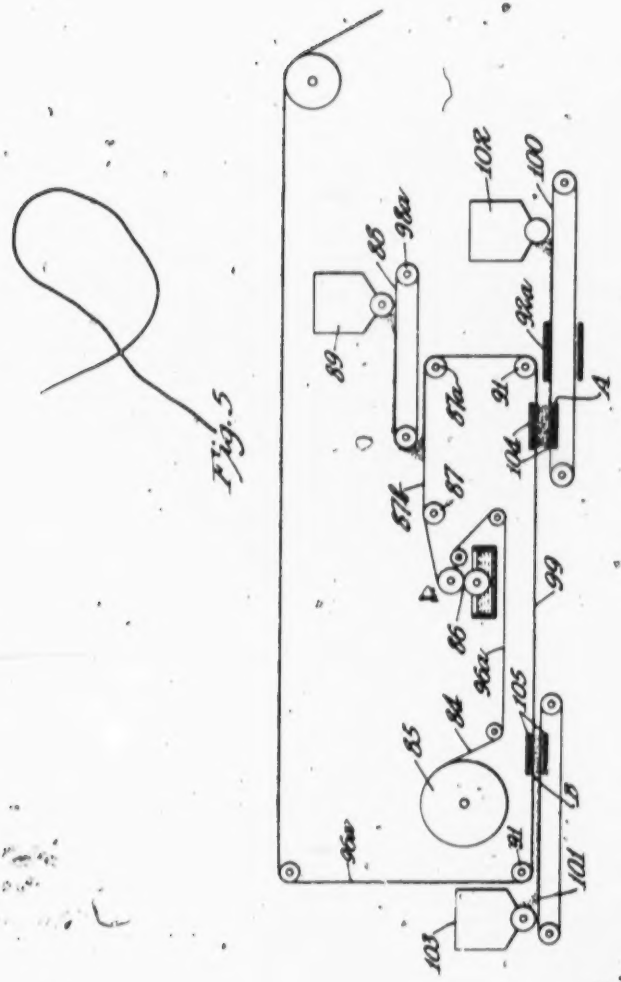
MANUFACTURE OF ABRASIVES

Filed July 28, 1942 3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,376,343

MANUFACTURE OF ABRASIVES

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Application July 26, 1943, Serial No. 495,823

6 Claims. (Cl. 117—27)

This invention relates in general to coated articles and to the art of coating, and more particularly to an improved method of and apparatus for applying pulverulent coatings to suitably adhesively coated surfaces, and while the invention finds particular utility in the art of making flexible abrasives, and is, therefore, described and illustrated for this purpose, it finds a wide field of utility for analogous purposes.

This application is a continuation of my co-pending application, Serial No. 427,089, filed January 26, 1930, now Patent No. 2,318,979, granted May 4, 1943.

It is well known that in the art of making sandpaper, emery paper or cloth and similar abrasive articles, a flexible or in some cases, a rigid, backing of paper, cloth, wood or the like is employed, to which is applied a coating of an adhesive substance, such as animal or vegetable glue, or where a waterproof article is desired, the backing may be coated with any of the now well known waterproof adhesives of the Ohio Patents 1,848,827, 1,869,892, of December 8, 1925, or 1,881,971 of April 20, 1926, for this purpose, and while the coating is still wet or tacky, a suitable abrasive material such as garnet, corundum, sand or the like is applied thereto. The grains of abrasive substances are usually applied by gravity upon the upper adhesive coated surface of the backing, and they lie in the adhesive material in haphazard fashion due to the elongated nature of the abrasive particles, and in a large degree, the facets or cutting edges of the individual grains or grits often lie flat upon or are embedded in the adhesive coating in such a manner that in some instances their best cutting edges never come into contact with the work or at best are brought inefficiently into contact therewith. The invention here has as one of its objects to measurably increase the number of grits whose longer or greater dimensions are in a plane perpendicular to the surface of the backing, thereby to present more efficiently the cutting edges to the work, and increase the cutting ability and life of the abrasive article.

It will be understood that in ordinarily depositing mineral, that is, pulverulent abrasive material solely under the force of gravity onto a backing, it acquires a velocity due to the action of gravity. As the grits pass through the intervening air space, there will be caused some change in their positions en route to the sheet or backing, but ordinarily neither the velocity given to the grits nor the effect of the air on them is sufficient to cause them to become aligned so as to assume positions substantially perpendicular to the backing. It is, therefore, necessary that independent force be applied to the grits, and I have found that by passing the grits through a static field of electric energy or of electro-magnetic energy or by mechanically imparting this force to the grits a much greater number of the individual particles will assume erect positions on the backing, which will enhance its cutting ability. As will later appear, my invention, in its several forms, is capable of application for operation in combination with gravity methods of applying the grit, inasmuch as under certain conditions, and for some purposes, it is desirable to employ both gravity and one of the forms of my invention in combination in order to attain a desired form of abrasive article.

In carrying out this invention, I find it desirable to employ a conveyor for conducting the mineral at not relative to the conveyor by relatively slow speed to a point adjacent to which the independent force is applied for projecting the particles of grit onto the backing. I find that by then applying this independent force, be it mechanical or electrostatic or electro-magnetic, I am able to impart a high velocity to the particle so that any force of gravity acting on the particle, whether in the same direction, in a counter direction, or in a direction angularly to that at which the force is applied, will be relatively small compared to this force applied. It is possible with the present invention to apply the force directly counter to gravity, that is, by bringing the grits beneath the backing or by applying the force in some other direction as long as the force of gravity and the effect of air is reduced below a point which will interfere with the result desired, namely, the projection of the grits with their longitudinal dimensions ultimately perpendicular or substantially so with respect to the backing.

The principal objects and advantages of this invention reside in the provision of an improved abrasive coated article, such, for example, as sandpaper, emery cloth, or the like, wherein the abrasive grits or grains lie in position on the backing for increasing the cutting effect and durability of the abrasive article; the provision of an improved abrasive article, wherein the abrasive grits are disposed so that their cutting facets are presented in position to more efficiently engage the work and thereby produce a sharper article; the provision of an improved abrasive article wherein the abrasive grains or grits are applied thereto with their longer or greater dimension substantially perpendicular to the plane of the

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backing; the provision of an improved abrasive article which may be flexible or rigid, as desired, and which may or may not be made waterproof, that is, suitable for employment in a water abrading operation.

This invention further includes as objects and advantages thereof, the provision of an improved method of and apparatus for manufacturing abrasive articles; the provision of an improved method of and apparatus for applying pulverulent material to one surface of a backing irrespective of the force of gravity, that is, against the normal tendency of the force of gravity; the provision of an improved method of and apparatus for propelling a pulverulent material, such as a grit or an abrasive grain, against an adhesive coated surface; the provision of an improved method of and apparatus for the purpose set forth and including electrically operated means for acting on an abrasive grain or pulverulent material and causing it to advance onto the adhesive coated backing irrespective of the force of gravity; the provision of an improved method of and apparatus for causing the particles of pulverulent material to impinge upon and assume a position in the adhesive coated surface substantially normal or perpendicular to the surface of the backing; the provision of an improved method of and apparatus for propelling a pulverulent material onto a moving sheet in a direction transversely to the plane of movement thereof and in a direction substantially counter to gravity; the provision of an improved method of and apparatus for making abrasive articles, such as sandpaper and the like, which includes the application of a grit to the under side of the backing; the provision of an improved apparatus which includes means for feeding and applying a pulverulent material counter to the force of gravity and simultaneously with movement of the backing; the provision of an improved means for moving a web of paper and applying an adhesive thereto and including means arranged below and for operating synchronously with for applying a pulverulent material to the under side of said moving backing; and the provision of an apparatus of the character described wherein improved electrostatic or electro-magnetic means may be employed, acting on the abrasive material and causing it to move at an accelerated speed toward the sheet so as to cause it to impinge thereon in the adhesive coating and thereby present the cutting edges of the abrasive grits away from the surface of the backing and thus increase the cutting ability and life of the abrasive article.

I have also found my invention useful as a modifying step in the employment of the conventional gravity process for applying grit in the manufacture of sandpaper or other abrasive and, therefore, additional objects of this invention reside in the provision of an improved method of interposing an additional step which will apply abrasive grains either before or after the application of grits by gravity in the usual manner, it being understood that the step of applying grit irrespective of gravity by an electro-magnetic or electrostatic means may be employed somewhere in the process of manufacture, the essential purpose being to increase the number of grits whose cutting facets are presented away from the backing and thereby to enhance the cutting ability of the finished article.

The apparatus of this invention includes a number of alternative forms for mechanically or electrically carrying out the steps of the process, and to this end is provided an improved pneum means and improved vibrator structure for chanically propelling the pulverulent mat and improved electro-magnetic structure for ing on the mineral and causing it to move cloud toward the adhesive coated surface o moving web or backing.

The foregoing and such other objects and vantages as may appear or be pointed out as description proceeds are attained in the st tures illustrated in the accompanying drawin which:

Figure 1 is a schematic view illustrating form of apparatus for carrying out the proce this invention;

Figure 2 is a view similar to Figure 1 of an a native form of the invention;

Figure 3 is a further alternative form of apparatus of this invention of employing chanical vibrating means;

Figure 4 is an enlarged schematic view i trating a portion of an abrasive article mad accordance with this invention;

Figure 5 is an additional form of apparatu carrying out further steps of the process of invention.

The method of the present invention incl as steps thereof the feeding of a web or stri paper or other fabric at a predetermined ra speed, applying an adhesive substance to under side of the sheet, or applying the adhe coating to one side and then moving the a with the coated side out, and simultaneously the movement of the coated sheet, causing a or abrasive material to be applied to this The sheet or web of paper may be moved so the adhesive coated side is either presented do wardly or at any angle thereto. The moven of the abrasive grains onto the under side of backing is done irrespective of the force of gra and, in fact, directly counter to gravity, and p erably done by imparting relatively high velo to the abrasive material, thus causing it to pinge upon the adhesive coating. In view of fact that the abrasive grains are proje through an intervening space from a suit carrier onto the adhesive coated side irrespec of or counter to the force of gravity, the gra which are usually somewhat elongated, will sume a position in transit so that the longer mension thereof will take a position norma the surface of the backing, thus causing grains to "stand" on the surface rather than flat in greater percentage than when they deposited by gravity. It is to be understood this movement of the grains and deposition them on the coated surface may be carried ou a number of ways, either by vibration, by an blast, or by electrostatic or electro-magn means.

In the alternative forms of this invention i to be described, the method involved inclu combining a gravity deposition of mineral on adhesively coated moving backing with the of applying the grits irrespective of gravity, being particularly useful in some of the hea grits wherein it may be found that the fo susceptible of application by an electrostatic an electro-magnetic means is not sufficiently tive on the available area of the individual g to cause an entirely satisfactory result or to m enough of the grits onto the sheet to attain desired end. In this invention it may be requi to apply some of the grit by gravity and s apply some of the grit by one of the method

this invention or vice versa, but, in any event, the number of grits in the entire finished article which stand erect on the backing will be measurably increased over the ordinary methods heretofore employed for depositing grit on a backing for forming an abrasive article.

This invention produces a very satisfactory piece of sandpaper in which the cutting ability is measurably increased and by the deposition of the grains of sand or grit irrespective of the force of gravity, it is possible to produce an orientation of the mineral as desired and to control the thickness of the abrasive coating much more readily than where gravity alone is relied upon or employed for depositing the grains on the sheet.

Referring now more particularly to Figure 1, the flexible backing 5 of paper or cloth or other fabric is trained or fed over a series of rollers 6, 6, and over one of a pair of the squeeze rollers, indicated at 7, the other roller 8 of said pair being in contact with an adhesive material contained in a tray or tank 9 by which an adhesive coating is applied to one side of the moving web. After receiving the adhesive coating, the web 5 is trained over rollers 10 and 11 and is brought back over a roller 12 so that the adhesive coated surface of said web is presented downwardly. The web may then be trained over rollers 13, 14, and fed to a suction drum 15, whence it passes into festoons for drying.

The mineral is supplied from a hopper 16 and a conventional outlet 17 which feeds a layer 18 of mineral to a moving conveyor 19. This conveyor 19 is preferably porous and passes over the feeding rollers 20 and 21 and is adapted to move at a suitable rate of speed to supply a sufficient quantity of abrasive grain. In some cases, it has been found advantageous to move the conveyor at a speed substantially the same rate of speed as the web 5, although these speeds are, of course, variables. The rollers 20 and 21 are mounted in the ends of a suitable frame 22, and this frame may be raised and lowered so as to vary the distance between mineral conveyor 19 and the moving web 5. This frame 22 may be supported fixedly at one end, as indicated at 23, and the other end may be raised and lowered by a toggle arrangement 24 activated by a threaded rod 25. Below the conveyor 19 and at the movable end thereof, that is, adjacent to the web 5, there is provided a second conveyor 26 which serves to conduct away excess mineral which flows over the end of the conveyor 19 and which may be returned in any suitable manner to the mineral hopper.

Below the upper flight of the conveyor 19, there are provided two air troughs 27. These air troughs are provided with flat upper walls 28, having slots 29 therein, said slots extending across the width of conveyor 19 and the troughs themselves being connected to a suitable source of air under pressure.

These troughs form in effect elongated jets or nozzles and when so placed below the conveyor belt or frame 22, a small quantity of air is emitted at high velocity which passes through the porous belt or conveyor.

It will be understood that when a blast or blasts of air are delivered from the troughs 27, this blast of air passes through the porous conveyor 19 and blows the mineral from the conveyor against the uniler side of the flight 18 so that the mineral is caused to strike into the adhesive at a relatively high velocity and becomes impinged therein. Owing to the projecting of the mineral in this manner through the intervening air space, the individual particles of grit or abrasive material are caused to assume a position parallel to their trajectory, that is, with their longer dimension perpendicular to the surface of the flight 18. In view of the fact that most of the particles of mineral are somewhat elongated, due to the manner of production of the same, they will naturally assume this position in movement from the conveyor 19 to the adhesive coated surface of the backing. As they arrive at the adhesive material, they impinge themselves thereon and will thus stand erect in the adhesive, thus forming a sharper contour for abrasive purposes. By varying the rate of speed of the moving backing relatively to the speed of the conveyor and by varying the distance between the conveyor and the backing and the velocity of the air stream, and by increasing or reducing the number of such jets and the quantity of adhesive applied, any reasonable desired thickness of grit layer may be produced during the process and without stopping the apparatus. It will be understood that the excess mineral carried by the conveyor may be dumped into the conveyor 26 and returned by any suitable means to the hopper 16.

Referring now to Figure 3, there is provided the same general arrangement of moving backing, having the flight 30 adhesively coated from the squeeze rollers 31.

Below the flight 30 there is provided a mineral feeding conveyor 19a, receiving pulverulent material from the hopper 16a.

The conveyor 19a is mounted for movement toward and away from the flight 30 similar to the conveyor 19 and, therefore, this structure has not been shown in Figure 3.

As the mineral flows from the hopper 16A it does not always assume a smooth or even distribution on the conveyor 19A, and, therefore, it may be desirable to provide a pair of charged electrodes 32, one arranged above and one below the conveyor 19A, for the purpose of spreading the mineral evenly on the conveyor belt. The conveyor 19A in this instance may be non-porous.

When charged electrodes are put in this position they act in principle the same as the charged electrodes used for coating the mineral on the backing. An electrical charge or difference of potential is set up between the electrodes 32. The voltage or difference in potential between these electrodes is maintained great enough to produce a strong static field, but not so great as to break down the insulation between the plates, which insulation may be the dielectric strength of the air or the dielectric strength of the air plus the dielectric strength of any insulating material which may be used to wrap the electrodes.

As the mineral on the conveyor enters the static field between the plates the mineral particles take on the charge of the lower plate, and are repelled to the upper plate where they lose their charge and take on the opposite charge of the upper plate. At this point they are repelled to the lower plate. Since new mineral is being conveyed by the conveyor into the field continuously the static fields soon become supersaturated with mineral particles, and an equilibrium is reached where as many particles are thrown out of the static field as are brought in by the conveyor. By having a down-turned end 32A of the upper electrode the mineral particles that are thrown out of the static field are deflected evenly on the conveyor belt so that a smooth

coating of abrasive grit is first placed on the conveyor.

The use of a static field for getting a smooth coating of mineral on the conveyor belt is not necessary to the invention but is an additional means of obtaining evenly distributed abrasive coatings, and is also a means for avoiding the use of any excess mineral on the conveyor. When the mineral is evenly coated on the conveyor at the time it is being coated, streaks, thin spots, etc., in the finished product are reduced.

At the same approximate point at which troughs 27 are provided in Figure 1 there are here provided electrically charged electrodes 33 and 34, the electrode 34 being located below the upper flight of the conveyor belt 18A and electrode 33 being disposed above the flight 20 of the backing. A sufficient difference of potential is maintained at electrodes 33 and 34 to produce a strong static field, similarly to that referred to above. This static field moves the mineral from the belt 18A to the underside, which is the adhesive coated surface of the flight 20.

As the mineral enters the static field between the electrodes 33 and 34 it becomes charged with the charge of the lower plate, and is here propelled to the upper plate 33.

It will be observed that in this method of coating the mineral is applied by a force other than gravity. In all other methods of coating sandpaper, known to me, the velocity of the particle is either in whole or part given to it by the force of gravity. In the case of this electrostatic coating the particles are oriented in the static field so that there is a tendency for the long dimension of the mineral to be perpendicular to the electrode plates, and also perpendicular to the web 20, which is being coated. The finished sandpaper product, therefore, contains a substantial percentage of the particles of mineral standing on end rather than laying flat, thereby increasing the cutting properties of the abrasive article.

Excess mineral is dumped onto the conveyor 35, whence it may be returned to the hopper 16a.

Referring now to the form of the invention shown in Figure 3, the moving web 20 is trained over a series of rollers similar to the arrangement shown in Figures 1 and 2 so that a horizontal flight 37 of the paper backing is provided, having an adhesive coating on the under side thereof. Squeeze rollers 36 engage the paper backing for applying an adhesive thereto.

In this form of the invention, a mechanical vibrating means is provided which serves to propel the mineral, that is, the grit, from the grit-feeding conveyor 38, which latter receives mineral from the hopper 39, having a gate 41. The conveyor 38 is trained over rollers 42 and 43 mounted in a suitable frame 44, which latter may be mounted for adjustment toward and away from the flight 37 similarly to the conveyor 18 of Figure 1. The conveyor 38 extends below and is separated from the flight 37 of the paper web and travels at substantially the same speed as the paper web.

The conveyor 38 passes between sets of pinch rollers, one above and one below the upper flight of the conveyor 38 as indicated by 45 and 46, and also beneath a pinch roller 47 which bears on the roller 43. The pinch rollers 45 and 46 tend to distribute the mineral evenly over the surface of the conveyor and are so spaced from the rollers 42 and 47 that the portion of the belt 38 between the rollers 45 and 46, and 43 and 47 is permitted to lie slack, whereas the remaining part of the conveyor is substantially taut. This arrangement tends to limit the vibration of the conveyor belt to the zone of application of the mineral to the paper backing, as indicated at 38.

Beneath the portion 38 of the belt 38, there is provided a revolving batter 48 operating on a shaft carried in suitable bearings in the frame 44 and provided with a plurality of radial arms 51 which upon rotation rigidly strike the under side of the portion 38 of the belt, thus throwing or projecting the mineral content thereof against the under side of the adhesive coated paper backing much in the manner in which the air stream blows the mineral or grit against the paper backing as shown in Figure 1. The batter 48 may be driven in any desired manner from a separate source of power or may be connected suitably with the rollers driving the belt 38, but geared to operate at a greater rate of speed. The rollers 45 and 46 and the roller 47 are separately driven from the belt 38 so as to produce the tautness in the belt, except the flight of the belt indicated at 38.

In Figure 4, there is illustrated an article made in accordance with the present invention. The backing is shown at 20 to which an adhesive coating 21 has been applied, and the grits, greatly enlarged, are indicated at 22, and it is noted that they stand on end in the adhesive coating, thus causing their sharper edges to project beyond the upper or outer surface of the coating, thereby enhancing the cutting ability and increasing the life of the abrasive article. While the article shown in Figure 4 is purely schematic, it will be understood that the mineral actually does take a position substantially normal to the backing and, while all of the grits may not take this position, a large number of the same do, and the cutting qualities of the abrasive article are thus greatly increased. Furthermore, by so disposing the grits, it permits of the application of an additional sizing coat or coats to the back and to the front or cutting face of the abrasive material without completely burying the grits and as a thicker coat of adhesive may thus be employed on the cutting face of the abrasive material, the engagement of the adhesive material with the abrasive material is greatly enhanced, thus further tending to increase the life of the abrasive article. Such a sizing coat is indicated at 23.

As previously pointed out, where the electrostatic or electro-magnetic methods are resorted to in some of the coarser grades of abrasive devices made, it may be found that the electrostatic or magnetic field into which the particles are conducted may not exert on each individual particle sufficient force to cause proper orientation of the particles, for the reason that the static effect is substantially proportional to the area of the particle, and the coarser the particle, the smaller the area of effect per weight. Therefore, as larger grits or sizes of particles are employed, increased force is required to move the particle, and for some purposes, insufficient increase in force results because of the reduced area per weight. Therefore, in such cases, a form of the invention, as shown in Figure 5 may be resorted to wherein the mineral is applied to the adhesively coated backing in part by gravity and in part by electrostatic or electro-magnetic means.

In view of the fact that the electrostatic and electro-magnetic means may for some purposes

be alternatively employed. I have illustrated in Figure 5 merely the electrostatic elements, though it will be understood that electro-magnetic means may be employed in the same manner.

Referring in detail to Figure 5, I have illustrated a web of paper 86 coming off a roll 88 and passing through an adhesive coating device illustrated in general at 90. The web 86 is thence trained over rollers 87, 87a, so that it has a substantially horizontal flight 87b, which receives grits in the desired amount from an ordinary conveyor 92, said conveyor receiving grits from the hopper 93. The web of paper thereon is carried downwardly to a horizontal flight 96 by the provision of rollers 94, 94, and an electrostatic or electro-magnetic or other grit applying means for applying grit counter to gravity may be employed at one or more points as indicated at A and B, wherein the conveyors 100 and 101 convey grit from suitable hoppers 102 and 103, and electrodes 104, 105 and 106, 107 serve to apply the grit.

As the web passes over the rollers 87a and 94, a quantity of the mineral deposited from the conveyor 92 onto the web will drop off, and, for conveying away this excess mineral, I provide a transversely running conveyor 95a arranged between the flight 96 and the conveyor 102.

It will be understood that while the electrostatic and electro-magnetic means for casting counter to gravity are illustrated in Figure 5, the mechanical means hereinabove described may be conveniently employed in these locations without departing from the spirit of the invention. However, the reason the electro-magnetic and electrostatic elements are particularly mentioned here is that the difficulty of counter casting successfully with the coarser grains is more likely to arise with these elements than with the vibrator or air blast heretofore described.

I wish to point out that where the expressions "electro-magnetic" and "electrostatic" are employed in the specification, I refer to the employment as well of a permanent magnet or some other form of static charge or magnetic charge which will perform the function.

Having thus described my invention and illustrated its use, what I claim as new and desire to secure by Letters Patent is:

1. The method of coating a backing with charged particles of material which includes the step or steps of first applying a coating of adhesive to a surface of said backing, then successively impinging increments of said particles against said adhesive coated surface until a plurality of successively applied increments have been deposited on the adhesive, the particles of at least one of said increments being coated on said surface by applying a propelling force, acting to project particles upwardly against the force of gravity from a preliminarily distributed layer spaced from said surface of said backing, and to direct the particles into contact with said adhesive coated surface, the propelling force being generated by an electrostatic field.

2. The method of coating a backing with charged particles of material which includes the step or steps of first applying a coating of adhesive to a surface of said backing, then successively impinging increments of said particles against said adhesive coated surface until a plurality of successively applied increments have been deposited on the adhesive, the particles of at least one of said increments being coated on said surface by applying a propelling force, acting to project particles upwardly against the force of gravity from a preliminarily distributed layer spaced from said surface of said backing, and to direct the particles into contact with said adhesive coated surface, the propelling force being generated by an electrostatic field and said layer being distributed upon a movable carrier spaced from said backing and moving through said field.

3. The method of coating a backing with particles of material which includes the steps of applying a coating of adhesive to a surface of said backing and applying the particles of said material to said adhesive coated surface in a plurality of successively applied increments thereof, the particles of at least one of said increments of material being propelled upwardly against the force of gravity into contact with said adhesive coated surface of said backing from a preliminarily distributed layer of said particles of material spaced from said surface of said backing by applying to particles in said layer, a propelling force generated by an electrostatic field, within which field said particles of said layer are disposed.

4. In apparatus for coating particles of charged material upon a backing, the apparatus comprising in combination, means for providing adhesive to said backing arranged to unite said material to said backing, at least one movable carrier for providing said material in a layer spaced from said backing, and means for propelling said material upwardly against the force of gravity comprising a plurality of successively arranged pairs of opposed electrodes creating successively effective electrostatic forces between said spaced electrodes, and means for passing said backing successively between said successively arranged pairs of electrodes, whereby as the backing passes between said electrodes, the adhesively coated backing is impinged by a plurality of successively applied increments of said material.

5. In apparatus in accordance with claim 4, wherein said opposed electrodes are plates which achieve orientation of a substantial number of the particles in substantially normal to the plates and the backing which is passed between the plates.

6. In apparatus for coating particles of material upon a backing, in combination, means for applying adhesive to said backing to hold said particles to said backing, means for propelling said particles upwardly against the force of gravity from the surfaces of movable carriers therefor to a surface of said backing coated with said adhesive, comprising a plurality of successively arranged pairs of spaced electrodes creating successive electrostatic fields, and means for passing said backing successively through said electrostatic fields between said electrodes and in spaced relation to said carriers whereby a plurality of separate increments of said particles of material are successively applied to said adhesive coated surface of said backing.

RICHARD PAUL CARLTON.

[fol. 823]

6

CERTIFICATE OF CORRECTION.

Patent No. 2,376,343. May 22, 1945.

RICHARD PAUL CARLTON.

It is hereby certified that error appears in the above numbered patent requiring correction as follows: In the heading to the printed specification, line 7, strike out the word "Application" and insert instead --Continuation of application Serial No. 422,065, January 20, 1930. this application--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 16th day of October, A. D. 1945.

Leslie Frazer

(Seal) First Assistant Commissioner of Patents.

[fol. 824]

May 29, 1945. W. H. KING 2,376,922

METHOD OF AND APPARATUS FOR MAKING PILE FABRICS

Filed June 4, 1941 2 Sheets-Sheet 1

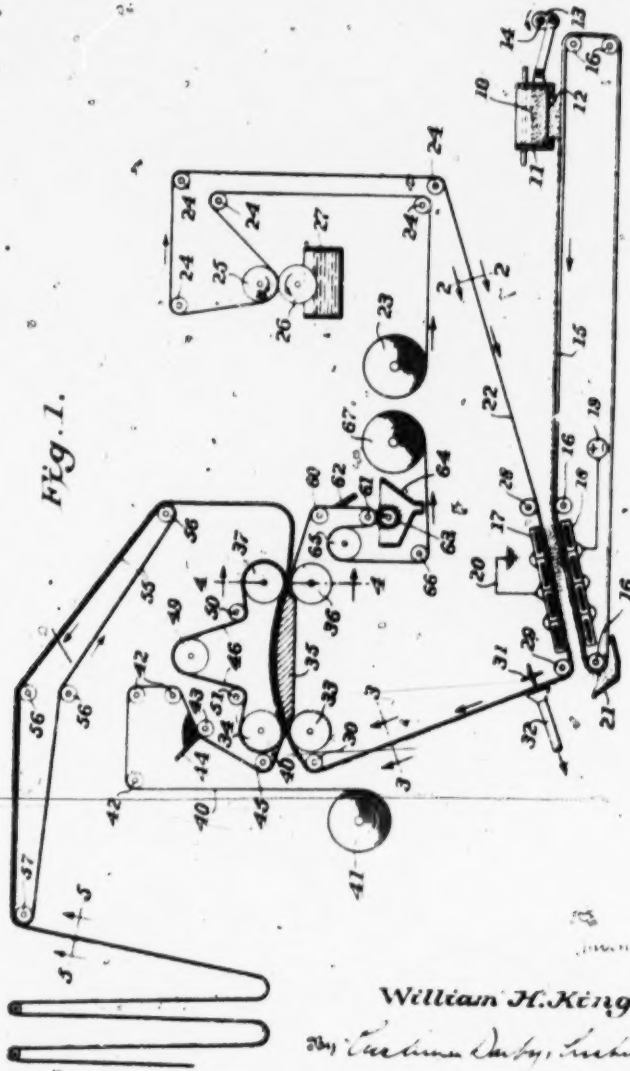

Fig. 1.

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METHOD OF AND APPARATUS FOR MAKING PILE FABRICS

Filed June 4, 1941 2 Sheets-Sheet 2

Fig. 2.

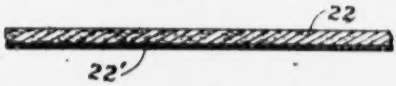


Fig. 3.

Fig. 4.

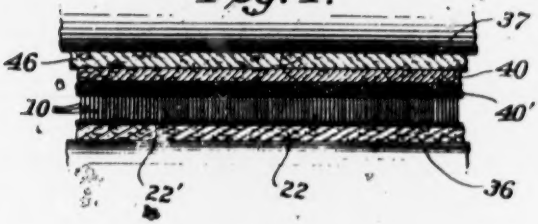
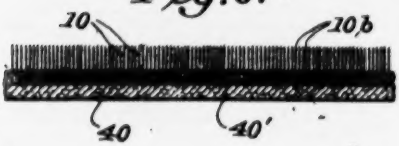


Fig. 5.



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[fol. 826]

Patented May 29, 1945

2,376,922

UNITED STATES PATENT OFFICE

2,376,922

METHOD OF AND APPARATUS FOR MAKING PILE FABRICS

William H. King, Troy, N. Y., assignor to Behr-Manning Corporation, Troy, N. Y., a corporation of Massachusetts

Application June 4, 1941, Serial No. 396,626

17 Claims. (Cl. 117—33)

The present invention relates to new and improved methods of and apparatus for coating, and more particularly, for coating flexible sheet material with fibrous products such as flock, in the production of pile surfaces and pile-surfaced materials.

The primary object of the invention is to produce pile fabric wherein the fibres forming the pile are adhesively united to the backing sheet in an improved, oriented position and by a bond of increased strength.

A further object is to produce a pile-surfaced fabric, wherein the pile-forming particles or flock are more deeply embedded, in oriented position, in the adhesive and are, therefore, more securely held in place.

Another object of the invention is to secure the pile-forming particles or flock to the adhesive with their outer ends spaced from the backing layer substantially exactly the same distance, to provide a more uniform surface appearance.

Another object of the invention is to provide a greater density of pile on the surface of pile fabric, than can readily be done with prior methods.

A further object of the invention is to provide a method which makes it possible to use a more viscous adhesive with certain types of pile-forming material than can be used with prior methods.

Another object is to provide a novel method of applying pile-forming material to a backing sheet in pattern form.

A further object is to provide positive control of the depth of penetration of the fibres into the adhesive and to control depth of penetration in accordance with the holding power of the adhesive.

A further important object of the invention is to produce a pile fabric product wherein the tops of the pile-forming fibres are all disposed in the same plane, equally spaced from the backing sheet, thereby giving the effect of a sheared pile fabric, such as velvet, without the necessity of employing a shearing operation.

Other and further objects and advantages of the invention will become apparent as the description of the invention proceeds.

Pile surface materials have heretofore been made by depositing pile-forming particles such as fibre or flock upon adhesively coated foundation materials. The particles have been oriented and arranged in parallelism, normal to the plane of the foundation material by mechanical agitation and by the use of electrostatic forces, or both. Examples of efficient electrostatic methods of depositing flock upon adhesively coated backing sheets may be found in the patents to Maston 2,173,675, Wintermute 2,173,032 and Amstutz 2,223,476.

It has also been proposed to subject the backing sheet to a beating or vibrating action as the flock is deposited, to effect orientation of the fibres. With such mechanical agitation, however, only a relatively small proportion of the fibres are disposed in parallelism, normal to the plane of the backing sheet. Moreover, with such mechanical orientation, the adhesion between the flock particles and the sheet is not sufficiently strong for all purposes.

In order to properly secure the flock to the backing sheet, it is desirable that the oriented particles penetrate the adhesive to a substantial extent and that the adhesive have good wetting characteristics for the flock. The viscosity of the adhesive has a major effect upon these factors, since, if the viscosity is low, the penetration of the adhesive by the fibres will be better and the wetting property will be increased. However, with certain adhesives, the first fibres that strike the adhesive will absorb a relatively larger quantity of the adhesive diluent or solvent than the adhesive solids, resulting in an increase of viscosity of the adhesive adjacent those particular fibres. The next fibres to be applied, therefore, encounter an adhesive layer of increased viscosity, with the result that they do not penetrate as far as the first-mentioned ones. Moreover, the last-mentioned particles absorb the adhesive diluent or solvent, when adhesives of the type referred to are being used, thereby further increasing the viscosity of the adhesive layer. This action proceeds as additional fibres are deposited, with the result that the viscosity progressively increases and the last fibres applied are only poorly secured. With the use of such adhesives, therefore, some of the fibres are very well anchored and other are not. Under wearing conditions, the loosely adhered fibres tend to drag with them, by their affinity, some of the other fibres that are more securely anchored, so that a pile surface material is produced, having wearing quantities that are unsatisfactory for certain uses.

The foregoing difficulties are particularly noticeable when latex adhesives are used, since the fibres tend to absorb water from the latex and increase the viscosity of the adhesive quite rapidly.

With the use of such adhesives, it has been found that, when the fibres are wetted, they acquire such an attraction for each other that their wetted ends are drawn together more than their

free dry ends, thereby producing a fanned or clumped effect and making it difficult for subsequently applied fibres to reach the adhesive. As a result, some of the fibres are anchored in a laid-down condition, which is undesirable.

In order to avoid these difficulties, when certain types of adhesives are used, it has been the practice in the flocking art to use adhesives of higher viscosity than that which would give the best penetration by the fibres and anchorage thereof to the backing sheet. With such high viscosity adhesives, the fibres are initially oriented upon the surface of the adhesive and attempts are then made to cause them to penetrate therein by the use of mechanical beaters and the like.

The foregoing difficulties are particularly pronounced when latex is used as the adhesive, since latex passes from a fluid liquid to a condition of relatively high viscosity upon the loss of very little water, an amount that is insufficient to properly wet enough of the fibres to provide a good flock layer. It is most desirable, however, to use latex as an adhesive medium, because of its economy and desirable final properties, and it is one of the objects of the present invention to provide a method of and apparatus for making latex an entirely satisfactory adhesive for use in the flock coating art.

When other types of adhesives are used, such as certain synthetic resin adhesives, however, the above-mentioned difficulties are not encountered, and the direct deposition methods described in the above identified patents are satisfactory for many purposes.

In accordance with the present invention, flock particles are deposited in oriented relation upon a transfer apron having a thin layer of relatively weak adhesive associated therewith, sufficient to hold, temporarily, the flock particles in closely packed oriented relation thereon, in parallelism, normal to the surface of the apron. The free ends of the flock particles so supported are then pressed, by mechanical pressure, into a layer of adhesive carried by a backing sheet, the last-mentioned adhesive having greater tenacity and strength than the first-mentioned temporary adhesive. The apron and the backing sheet are then moved apart and the flock particles stripped from the former are carried by the adhesive associated with the latter. The sheet so produced is then subjected to the usual drying and curing steps to produce a finished product.

The invention will be understood more fully by reference to the accompanying drawings, wherein an illustrative embodiment of the invention is illustrated diagrammatically.

Although the specific embodiment of the invention described below includes the electrostatic orientation and deposition of the pile-forming fibres upon a transfer surface, it must be understood that the invention is not confined to that type of orientation and deposition, since many of the advantages of the invention are applicable to gravity depositing and mechanical orienting methods.

In the drawings:

Figure 1 is a diagrammatic side elevation of an apparatus capable of performing the method of the invention, and

Figures 2, 3, 4 and 5 are greatly enlarged, fragmentary diagrammatic sections taken on lines 2—2, 3—3, 4—4 and 5—5 of Figure 1, respectively.

Loose flock material 10, of any suitable kind (such as that described below in connection with a specific example of the method of the invention), may be deposited by hand or by conventional conveying means into a hopper 11 having a screen bottom 12, the hopper being mounted for agitation or vibration under the influence of a crank 13 carried by a continuously rotating shaft 14, driven by appropriate means, not shown. A feed belt 15, trained about and driven by suitable rollers 16, receives the sifted flock in an evenly distributed layer from the hopper and carries the same through an electrostatic field between upper electrodes 17 and lower electrodes 18, the latter being connected to a suitable source of current 19 and the former connected to ground at 20. A trough 21 at the end of the flight of the feed belt 15 receives any material not deposited by the electrostatic field.

A transfer apron 22, unwound from a roll supply 23, is trained over rollers 24 and through a pair of rollers 25, 26, the latter of which dips into an adhesive receptacle 27 and applies a coating of adhesive to the apron. The apron is drawn, from the last guide roller 24 beneath additional guide rollers 28, 29, by a roll 30 through the electrostatic field, adjacent the upper electrode 17. In the electrostatic field, the flock particles are projected upon and are secured to the adhesively coated transfer apron 22, as is well understood in the electrostatic flocking art. Flock particles not adequately secured to the apron may be removed by a light beater 31 and a suction device 32.

Beyond the upper roll 30, the transfer apron passes between the first pair of rollers 33, 34, over a supporting platform 35 having a convex arcuate upper surface, and then between a second pair of rollers 36, 37.

A sheet of backing material 40, drawn from a roll supply 41, passes over rollers 42 and through an adhesive coating apparatus comprising a roller 43 and a doctor blade 44, so that one surface of the sheet is coated with an adhesive, of a type described below in connection with a specific example of the method. The sheet is trained for movement under a power driven guide roll 45 and then between the first pinch rolls 33, 34 and the second pinch rolls 36, 37, in superimposed relation to the free ends of the flock particles on the apron 22, the apron being supported by the arcuate platform 35.

A backing-up, pressure-applying blanket 46 is trained about rollers 34, 37, 46 with one of its flights directly behind and above the coated backing sheet 40. The degree of pressure applied by the blanket 46 to the backing sheet and by the backing sheet to the flock particles on the transfer apron may be controlled by adjustably mounted idler rollers 50, 51 which control the tension in the blanket.

The backing sheet 40 and the flock particles embedded in the adhesive coating thereon move away from the transfer apron, with the result that the flock particles are stripped from the latter. The sheet is led upwardly to and carried by the upper surface of an endless conveyer 55, trained about guide rollers 56 and a driven roller 57. The backing sheet moves with the conveyer 55 for a sufficient time to permit the adhesive to dry somewhat, whereupon the sheet is delivered to further drying and curing means, not shown.

The transfer apron 22 is guided over rollers 58, 61, past a scraper blade 62 and a rotating brush 63, which effectively clean the surface of the apron, the matter removed being received in a trough 64 which may be connected to suction removing means. The apron next passes over a positively driven roll 65, an idler 66 and is wound

[fol. 828]

up in a roll 67, which may eventually be removed and re-used.

Instead of using a long, discontinuous transfer apron 22, adapted to be unwound from the roll 23 and rewound into the roll 67, it is entirely feasible to employ a continuous, endless apron. In such case, one flight of the apron passes directly from the roller 66 through appropriate tension rollers, not shown, to the roller 24, the apron being cleaned by the blade 62 and the brush 63 before it receives its next coating of adhesive. Instead of using a transfer apron or belt, the invention contemplates the employment of a relatively large transfer cylinder or drum which may itself constitute one of the electrodes for the electrostatic field or which may have its periphery arranged to revolve through the space between a pair of fixed, arcuate electrodes, so that, in any event, the fibres are deposited on the periphery of the cylinder which has previously been coated with a relatively weak adhesive. The particles in this case may be transferred to the backing sheet by means similar to that shown in Figure 1, the periphery of the drum constituting the equivalent of the arcuate apron supporting platform 26.

The adhesively coated, final backing sheet 69 may be brought into contact with the free upper ends of the flock secured to the transfer apron 22 immediately upon the entrance of the sheet and the apron between the bite of the rollers 33, 34, or, on the other hand, the contact between the adhesive on the backing sheet and the flock layer can be made to take place at a point between the first rollers 33, 34 and the second rollers 36, 37, so as to provide a more gradual penetration of the fibres into the adhesive. In fact, the latter procedure is preferred and the second pair of rollers 36, 37 are carefully set so as to assure the proper depth of final penetration of the fibres into the adhesive layer on the permanent backing sheet. The backing-up blanket 68 which forces the coated sheet 69 onto the flock particles is desired as a means for accurately controlling the pressure between the two and as a means for preventing wrinkles and the like in the sheet. In many cases, particularly when a relatively heavy permanent backing sheet is used, the blanket 68 may be eliminated.

The invention contemplates applying flock in pattern form and this may be readily accomplished by printing, stencilling, or otherwise applying to the transfer apron, a weak adhesive layer according to a predetermined design. In such case, the flock will be applied to the transfer apron only over the area covered by the design and the flock so deposited will be transferred to the permanent backing in the same manner, so that the design will appear on the finished product. In the alternative, the adhesive on the backing sheet 69 may be applied by printing, stencilling, or the like in any desired pattern or design, in which case the continuously and evenly coated apron 22 will apply the pile-forming material only to those portions of the permanent backing which have been adhesively coated, with the result that the pile surface in the finished product will follow the desired pattern or design. This method is preferred in some cases, since it results in a saving of the amount of final adhesive employed and produces a finished product wherein the nonflock coated portions of the finished product are not adhesively coated.

Many types of rubber cement and latex adhesives may be used for the permanent backing sheet, in accordance with the present invention. The following example is satisfactory:

Adhesive example

	Formula #1	Formula #2
	Parts	Parts
Rubber at 60% latex	100	100
Zinc oxide	2	3
Sulphur	1	1.5
Zinc dibutyldithiocarbamate	1	
Diisopthyl-p-phenylenediamine	1	
Zinc salt of 2-mercaptobenzothiazole	1	1
Dipentamethylene-thiuram-tetrasulfide		1.5
Casein (as 28% NH_4 sol.)		.35
Water (total)	4	4
	57	56.75

The above formula may be prepared by methods well known in the latex compounding art. Usually the pigments are ground with an equal weight of water in a ball mill until good dispersion is obtained. The casein solution is first added to the rubber latex after which the dispersed pigments are stirred in. After the fibres are embedded in the above adhesive, the water can be evaporated by suspending the finished material in air at 180° F. for 15 minutes. After the material is dry, it can be vulcanized and in the case where the above formula #1 is used, it can be cured for 30 minutes at 220° F.; where the above formula #2 is used, it can be cured for 10 minutes at 260° F. to give satisfactory results.

While my process and apparatus have peculiar advantages for the use of rubber latex in anchoring the fibres to the backing, but they are not limited to latex, but may be used with a wide variety of adhesives. In particular, my process and apparatus are well adapted for use where the adhesives consist of re-dispersed rubber or water emulsions of synthetic resins for the reasons already pointed out in connection with latex; that is, I overcome the difficulties incident to the ready absorption of water by many of the fibres used in making pile fabrics. I may also use rubber cement or solutions of various flexible resins in organic solvents for my adhesive.

The following examples give suitable temporary adhesives for application to the transfer apron 22:

Temporary adhesive Example 1

	Per cent
Glycerine	70
Alcohol	25
Water	5
	100

The method of preparing this mixture is well known to those skilled in the art.

The alcohol merely serves to dilute the mixture so that a very thin film can be applied to the surface of apron 22, and the water is present to reduce fire hazard, in the event that some of the alcohol does not evaporate before the coating reaches the electrostatic field.

Temporary adhesive Example 2

A very light coating of glycerine.

Temporary adhesive Example 3

Grind in a ball mill 75 parts of bentonite clay in a mixture of 75 parts alcohol and 100 parts glycerine. After this is thoroughly dispersed, pour in a mixture of 50 parts water with 10 parts alcohol. This gives a mixture that has proper-

[fol. 829]

ties that will enable it to be coated onto a transfer apron by means of a doctor blade. Enough time should be allowed so that the alcohol can evaporate before the apron enters the electrostatic field. This mixture is coated onto the transfer apron which may or may not have been previously prepared by coating with a mixture of casein,—water—28% NH_3—glycerine and whiting. A heavier coating of Example 3 is required than of Examples 1 or 2. The transfer apron has to be re-coated each time it is used.

A specific example in accordance with the method of the present invention will now be described, wherein the method and apparatus of the present application have been employed in the manufacture of automobile body, side-wall material, consisting of a fabric backing coated with a latex adhesive on which is deposited oriented rayon fibres. Referring to Figures 1 and 2, three denier rayon fibres 18, .020" long and dyed green properly processed by the supplier are placed in the hopper and are sifted through the vibrating screen in a thinly, uniformly and evenly distributed layer on the rubberized-fabric, endless feed belt 15, which is travelling at the rate of about 50 feet per minute. It is understood, of course, that this speed can be varied more or less depending upon the density of the flock desired. The feed belt is run much faster than the transfer apron, so that the flock can be thinly distributed thereon, with the result that the orientation of the fibres is improved and the deposition of a dense pile coat on the transfer apron is facilitated.

The transfer apron, wound up into roll 21 is is 1200 kraft paper which has previously been treated as follows. A mixture of the following:

	Per cent
Casein	8
Water	48
28% NH_3	3
Glycerine	20
Whiting	20

is applied in a thin layer to the paper by means of a doctor knife or a pair of squeeze rollers. 140 pounds of wet weight of this formula, applied in the approximately even coats, will cover about 1,120 yards of the paper 60" wide. When it has dried, the casein is fixed by an application of a light coating of formaldehyde such as 10% solution in water. After evaporating the water, the paper apron is rolled up into roll 21, from which it is unwound and drawn through coating rollers 22, 23 where it receives a coating 22' (Fig. 2) of the temporary adhesive, made as follows:

	Per cent
Glycerine	70
Alcohol	25
Water	5
	100

Five pounds wet weight of this material will coat about 100 yards of transfer apron 60" wide. In its further passage over idler rollers, evaporation of the liquid adhesive diluent takes place so that upon arrival at the electrostatic field, an extremely thin film of temporary adhesive is present on the surface of the paper. The transfer apron used in this particular example is approximately 60" wide, so that it extends about 1" to each side of the fabric to be coated, and is about 200 yards in length, and is run at a speed of about 10 feet per minute. The transfer apron can be run at speeds of from 2 feet to 50 feet per minute or more. However, any speeds faster than 10 feet per minute may require longer electrodes along the distance of travel of the web in order to acquire sufficient density of fibres on the transfer apron. The distance from the coating rollers 22 and 23 to the sets of electrodes 17 and 18 is about 22 feet.

The electrostatic field used in this particular instance is about 80" long in the direction of the travel of the web. Forty thousand volts are used with a 25 cycle alternating current. The distance between the electrodes 17 and 18 is approximately ¾". It is understood, of course, in other cases that different voltages, current frequencies and electrode spacings can be used and satisfactory deposits obtained. Also D. C. and pulsating D. C. current can be used. In this particular instance, very good flock deposition has been obtained if the atmosphere in the electrostatic field is maintained at a relative humidity of 40 to 50% at a temperature of 70° to 80° F.

The feed belt passes into this electrostatic field facing upwardly travelling along the lower electrode. The transfer apron, with the temporary adhesive facing downwardly, passes into and through the electrostatic field next to the upper electrode and the flock particles on feed belt are electrostatically charged, oriented and deposited on the transfer apron 22, to produce an oriented layer of flock, as shown in Figure 3. The upper ends 19a of the fibres 19, which eventually become the tops of the fibres in the finished product, all project through the thin coat of adhesive 22' and contact the apron 22, with the result that these ends are exactly aligned and lie in the same plane. Any minute irregularity that may exist through inadvertence in the length of the fibres, will show at their opposite ends 19b.

After the transfer apron passes through the electrostatic field, it is directed upwardly around idler roller 30 past the light bumper 31 and then around the power-driven roller 32 between the lower nip roller 33 and the upper roller 34. It is drawn over the supporting platform 35 and through the second nip rollers 36, 37. The supporting platform having the accurate surface can be made of any suitable material such as wood or metal having a smooth upper surface. To get a smoother and more frictionless surface, it may even be veneed although this is not necessary. The length of this accurate surface of the platform is approximately 36⅛" and the radius of curvature of the upper surface is approximately 12" 2⅛", although these dimensions are not critical. The extreme ends of this are not disposed as closely as possible to the bite of the rollers 33, 34 and 36, 37. The distance from the coating electrodes to nip rollers 33, 34 is approximately 22 feet, although this distance is not critical. The amount of flock deposited on the transfer apron amounts to approximately three ounces per square yard for this denier flock and length. This may be guaranteed to give a density of about 200,000 to 300,000 fibres per square inch.

The backing which I have used in this particular instance is a 60" drill dyed brown having a weight of 1.92 yards per pound with a count of 60 x 48. The fabric as it is obtained from the cloth mills, being 62" wide, is given a filler or size treatment consisting of applying, by means of a doctor blade or coating rollers, a size which is made by the same formula given in the Adhesive example, formula 2. If a thinner size is

[fol. 830]

desired, the amount of casein can be decreased. This size is applied to the cloth at a rate which will amount to 1¼ ounces of dry compounded rubber from latex per square yard. This treatment is not necessary in every instance. In order to obtain better anchorage of the size coating, I find that it is preferable to scour and bleach the fabric before the dyeing and sizing steps are performed. This cloth is then calendered before or after the size treatment to give a smooth coating, although I prefer to calender the cloth after the size coating has been applied. The cloth by this time has shrunk in width to approximately 58".

This coated cloth 40 is unrolled from roll 41 and is drawn through the adhesive coating apparatus, where the adhesive made up as previously described in the Adhesive example, formula 2, is applied to the cloth by means of a doctor blade. In this particular instance, we desire to deposit on the cloth a latex film of .013" thickness. Therefore, the doctor blade is set .013" from the surface of the cloth. This will apply a coating 40' of latex to the cloth amounting to five ounces of dry compounded rubber from latex per square yard. This latex coated cloth then passes around and is pulled by power-driven roller 43 and passes around nip roller 34 and is pressed against the flock formation on transfer apron 22 by the endless belt 46 which is made of rubberised cloth and is approximately 60" wide. I maintain enough tension on the belt 46 to force the ends 10b of the fibres 10 into the latex to the required depth without crushing or disturbing the orientation of the fibres (Fig. 4). In this particular instance, the space between nip rollers 33 and 34 is such that the distance between the surface of the transfer apron 22 and the surface of the supporting belt 46 is ¼". The space between the nip rollers 36 and 37 is maintained so that the distance between the surfaces of the transfer apron 22 and the supporting belt 46 is .040". Since the thickness of the backing 40 is .013" and the thickness of the latex film is .013" and the length of the fibres to be deposited is .030", a total of .083", the fibres 10 are gradually forced into the adhesive 40' between the nip rollers until they substantially touch the surface of the fabric 40. Since the thickness of the fabric is .013" and the length of the fibre is .030" amounting to .043". It will be seen that the fibres in passing between nip rollers 36 and 37 are bent .069". This is not enough to crush the fibres or disturb their orientation, but will force them through the total thickness of the adhesive film 40'. It is found that these fibres penetrate the adhesive film to the depth of .011" with .019" of the fibres remaining exposed above the surface of the adhesive. If some of the fibres are inadvertently shorter than the standard length, they will not be pressed as deeply into the adhesive 40', but their top ends 10a will still be exactly aligned with the other, standard length fibres.

The purpose of the arcuate surface or platform 38 is to force the transfer apron upward and create an arc in the transfer apron 22, supporting belt 46 and backing sheet 40, so that tension can be placed on the sheet 40, holding it firmly against the fibres 10 on the transfer apron. Figure 4 illustrates quite clearly how these fibres 10 are forced through the adhesive layer 40' to the surface of the fabric 40. It is understood that the adhesively coated fabric travels at the same rate of speed as the transfer apron 22, that is, 10 feet per minute.

Although belt 46 can be driven at a synchronous speed with transfer apron 22, it has been found in actual practice that enough power to drive it is obtained through its contact with the backing sheet 40, which, in turn, is in frictional contact with the flock coated transfer apron 22.

In this process, the fibres 10 are more securely attached by the adhesive film 40' to the fabric 40, so that when this fabric is separated from the transfer apron 22, as shown in Figure 5, the flock is so securely anchored by this permanent adhesive film that it is entirely pulled loose from the temporary adhesive film 22' on the transfer apron.

After the flock coated cloth leaves the nip rollers 36 and 37, it is fed for a distance of approximately 3 feet in a slack condition and then on to supporting the belt 50 which is trained around rollers 56, and driven at the same speed as the backing sheet and transfer apron. The temperature around belt 50 is at room temperature and the coated fabric is supported thereon for a distance of approximately 20 feet, at which point coated fabric is festooned and passed through a drying room. The cloth remains in the drying room, which is maintained at a temperature of 180° F., for 15 minutes, whereupon it passes into a vulcanising chamber, where it remains for 10 minutes at a temperature of 260° F. The material is then cooled, taken down and rolled up.

The final vulcanised fabric has gradually shrunk to a width of 55" and the total weight of the fabric plus the rubber plus the fibre amounts to 14 ounces per square yard. The weight of the cloth in the finished product is 6 oz./sq. yd. The weight of the flock in the finished product is 3 oz./sq. yd. The weight of adhesive (dry compounded rubber from latex) is 5 oz./sq. yd.

It must be understood that the present invention is not limited to the specific method steps described above, or to the details of construction of the apparatus shown in the accompanying drawings, but covers all modifications as to method and apparatus, coming within the scope of the appended claims and their equivalents.

I claim:

1. The method of forming pile-surfaced material which comprises coating a transfer surface with a relatively weak adhesive, depositing on said coating a layer of pile-forming material in oriented relation with the particles thereof substantially normal to said surface, coating a backing sheet with a stronger adhesive, bringing the coated surface of the latter sheet into contact with the pile-forming material on the transfer surface, and transferring the pile-forming material from the transfer surface to the sheet while maintained in oriented position.

2. The method of forming pile-surfaced material which comprises applying to one surface of an elongated apron a thin coating of a relatively weak adhesive, depositing on the coated surface of the apron a layer of closely packed pile-forming fibres in oriented relation with the fibres substantially normal to said surface, applying a relatively thick coat of a stronger adhesive to one surface of a backing sheet, bringing the coated surface of the latter sheet into contact with the free ends of the fibres on the apron and embedding said ends in the thick coat of stronger adhesive, and stripping the pile-forming material from the apron and transferring the same to the

backing sheet while the fibres are maintained in oriented position.

3. The method of forming pile-surfaced material which comprises continuously moving an apron having a relatively weak adhesive coating on one surface thereof through an electrostatic field, depositing upon said adhesive coating, under the influence of the field, a layer of pile-forming material with the particles thereof in oriented position, and continuously transferring the oriented layer of pile-forming material to an adhesively coated backing sheet in oriented position.

4. The method of forming pile-surfaced material which comprises electrically depositing a layer of pile-forming material, such as flock, upon an adhesive coated apron in oriented position with the individual particles disposed in substantially normal relation to the apron, coating a backing sheet with a coating of a stronger adhesive than the adhesive on the apron, continuously moving the sheet and the apron along converging paths to cause the pile-forming particles on the apron to penetrate the adhesive on the sheet, and separating the apron and the sheet to cause the pile-forming material to be transferred from the former to the latter.

5. The method of forming pile-surfaced material which comprises continuously depositing on a moving feed belt, a layer of loose, comminuted pile-forming material such as flock, coating an apron with a relatively weak adhesive, conducting the apron and the belt through an electrostatic field and thereby causing the flock to be deposited in oriented relation upon the adhesive coating on the apron, coating a backing sheet with a stronger adhesive, conducting the apron and the sheet into such proximity that the coating on the sheet contacts the oriented flock on the apron, and separating the apron and the sheet, thereby causing the flock to be transferred from the former to the latter.

6. The method of forming pile-surfaced material which comprises sifting onto a relatively rapidly moving feed belt a layer of loose, comminuted pile-forming material such as flock, coating a transfer surface with a thin layer of relatively weak adhesive, conducting the transfer surface and the belt through an electrostatic field with the transfer surface moving at a slower speed than the belt and thereby causing the flock to be deposited in closely packed and oriented relation upon the adhesive coating on the transfer surface, coating the backing sheet with a relatively thick layer of a stronger adhesive, conducting the transfer surface and the coated backing sheet at the same rate of speed into such proximity that the free ends of the oriented flock on the transfer surface penetrate the adhesive on the sheet, and then separating the sheet from the transfer surface, thereby causing the flock to be stripped from the transfer surface and transferred to the sheet.

7. The method of forming pile-surfaced material which comprises depositing upon a continuously moving transfer surface having a relatively weak coating of adhesive thereon, a closely packed layer of pile-forming material in oriented relation with the fibres thereof substantially normal to said surface, causing the transfer surface to follow an arcuate path with the coated side convex, moving a backing sheet having a coating of relatively strong adhesive along said arcuate path with the adhesive coated side facing the transfer surface, applying pressure to the backing sheet to cause the oriented fibres to penetrate the adhesive thereon, and thereby transferring the fibres to the backing sheet.

8. The method of forming pile-surfaced material which comprises depositing on a transfer apron having a coating of relatively weak adhesive thereon, a layer of closely packed pile-forming material such as flock with the fibres thereof oriented and disposed substantially normal to the apron, moving said apron along an arcuate, convex path, coating a backing sheet with a layer of relatively strong adhesive, moving the backing sheet along a path following the arcuate path of movement of the apron with the adhesive on the concave side, and bringing the layer of relatively strong adhesive into contact with the fibres on the belt during such movement, whereby the fibres in oriented position are transferred to the backing sheet.

9. The method of forming pile-surfaced material which comprises coating a transfer apron with a thin coating of a relatively weak adhesive, depositing on said coating a layer of closely packed pile-forming material in oriented relation with the fibres thereof substantially normal to said surface, coating a backing sheet with a relatively thick layer of a stronger adhesive dispersed in a medium containing water, bringing the coated surface of the latter sheet into contact with the pile-forming material on the apron, and transferring said material from the apron to the sheet while maintained in oriented position.

10. The method of forming pile-surfaced material which comprises coating a transfer apron with a thin coating of a relatively weak glycerine adhesive, depositing on said coating a layer of closely packed pile-forming material in oriented relation with the fibres thereof substantially normal to said surface, coating a backing sheet with a relatively thick layer of a stronger, rubber latex adhesive, bringing the coated surface of the latter sheet into contact with the pile-forming material on the apron, and transferring said material from the apron to the sheet while maintained in oriented position.

11. The method of forming a sheet of pile-surfaced material in simulation of sheared pile fabric, but without shearing the pile and wherein the outer ends of the pile-forming fibres all lie in the same plane which comprises coating a moving transfer surface with a relatively weak adhesive, depositing on said coating, in oriented relation, a closely packed body of pile-forming fibres cut to substantially the same length with the axes of the fibres substantially normal to the transfer surface and with the ends of the fibres substantially in contact with the surface and lying in a common plane, coating a backing sheet with a relatively thick layer of a stronger adhesive, bringing the coated surface of the latter sheet into contact with the outer ends of the pile-forming fibres on the transfer surface and causing said ends to penetrate the relatively thick layer of adhesive, and stripping the fibres so secured to the backing sheet from the transfer surface, whereby the ends of the fibres formerly in contact with the transfer surface become the outer ends of the pile and all lie in the same plane.

13. An apparatus for forming pile-surfaced material made up of a backing sheet and pile-forming fibres adhesively secured thereto, comprising a continuously moving transfer surface, means for forming on said surface a layer of said pile-forming fibres in closely packed oriented rela-

tion with said fibres disposed substantially normal to the surface and weakly secured thereto by adhesive, and means for continuously moving and guiding said backing sheet having a relatively strong layer of adhesive thereon into transferring contact with the free ends of the pile-forming fibres on the transfer surface, whereby the pile-forming material is transferred in oriented relation from said surface to the adhesive on the backing sheet.

13. An apparatus for forming pile-surfaced material made up of a backing sheet and pile-forming material adhesively secured thereto, comprising a transfer surface, means for lightly securing to said surface a layer of the pile-forming material in closely packed, oriented relation with the fibres substantially normal to the surface, means for moving the transfer surface along a convex arcuate path, means for guiding the backing sheet having a coating of relatively strong adhesive thereon along a path following said arcuate path of movement and with the strong adhesive in contact with the fibres, and means for moving the sheet away from the transfer surface to strip the pile-forming material therefrom.

14. An apparatus for forming pile-surfaced material comprising a transfer surface having a coating of relatively weak adhesive thereon, electrostatic means for depositing on said surface a single layer of pile-forming fibres in oriented relation, and means for continuously and progressively moving an adhesively coated backing sheet into transferring relation to the free ends of the oriented pile-forming fibres, to strip the same from said transfer surface and to secure the same to the sheet in oriented relation.

15. An apparatus for forming pile-surfaced material comprising means for producing an electrostatic field, means for delivering comminuted flock to the field, means for continuously moving an adhesively coated transfer apron through the field in position to receive the flock in oriented relation by electrostatic deposition, means for continuously moving the apron along a predetermined path outside of the electrostatic field, means for moving a coated backing sheet, means outside of the electrostatic field for guiding said sheet to bring the adhesive coating thereon into contact with the flock on the apron, and means for continuously separating the apron and the backing sheet to strip the flock from the former and to transfer the same in oriented position to the latter.

16. The method of forming pile-surfaced material which comprises coating a transfer surface with a relatively weak adhesive, depositing on said coating a layer of pile-forming fibres such as flock, embedding only one end of each of a substantial proportion of the fibres in said relatively weak adhesive, coating a backing sheet with a substantially stronger adhesive than the first-mentioned adhesive, bringing the coated surface of the backing sheet into contact with the fibres on the transfer surface to embed one end only of each of a substantial proportion of the fibres in the latter adhesive, separating the sheet and the surface and thereby transferring the fibres from the surface to the sheet.

17. The method of forming pile-surfaced material which comprises coating a continuously moving transfer surface with a relatively weak adhesive, depositing on said coating a layer of pile-forming fibres such as flock, embedding one end only of each of a substantial proportion of the fibres in said relatively weak adhesive, coating a continuously moving backing sheet with a substantially stronger adhesive than the first-mentioned adhesive, continuously bringing the coated surface of the backing sheet into contact with the fibres on the transfer surface to embed one end only of each of a substantial proportion of the fibres in the latter adhesive, and continuously separating the sheet and the surface and thereby transferring the particles from this surface to the sheet.

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[fol. 833]

Aug. 17, 1948. J. S. SMYSER 2,447,374

METHOD OF APPLYING COATING MATERIALS

Original Filed April 20, 1934 3 Sheets-Sheet 1

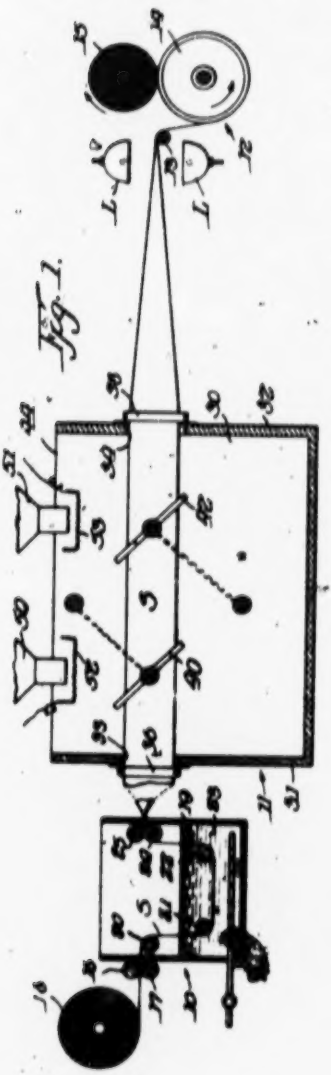

Fig. 1.

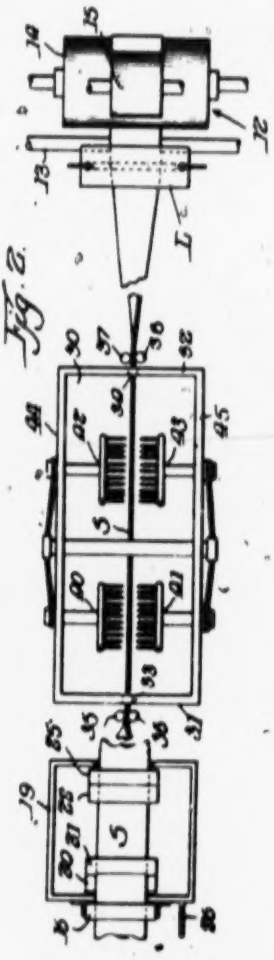

Fig. 2.

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Aug. 17, 1948. J. S. SMYSER 2,447,374

METHOD OF APPLYING COATING MATERIALS

Original Filed April 25, 1934 3 Sheets-Sheet 2

Fig. 5.

Fig. 3.

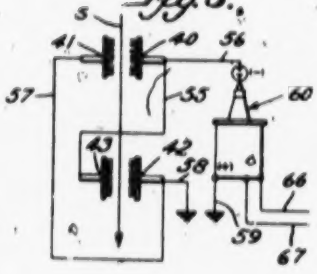

Fig. 6.

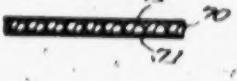

Fig. 4.

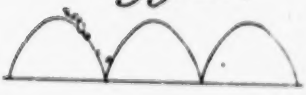

Fig. 11.

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Aug. 17, 1948. J. S. SMYSER 2,447,374

METHOD OF APPLYING COATING MATERIALS

Original Filed April 25, 1934 3 Sheets-Sheet 3

Fig. 7.

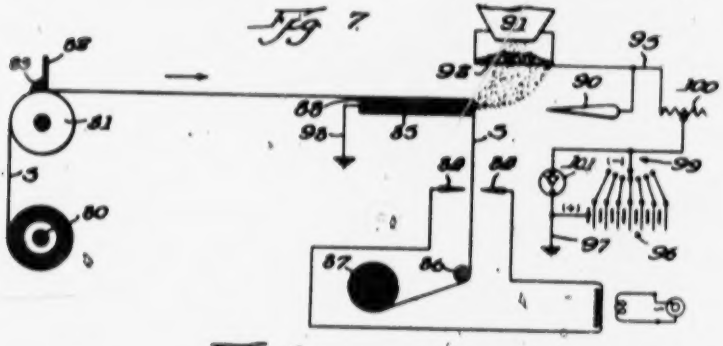


Fig. 8.

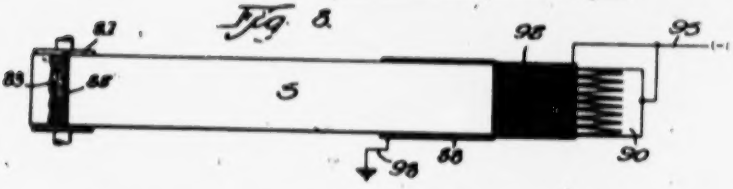


Fig. 9.

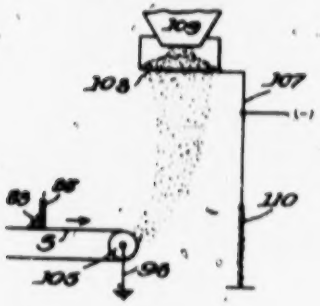
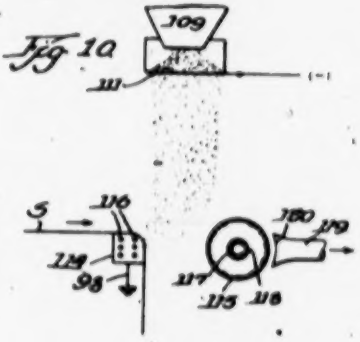


Fig. 10.



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Patented Aug. 17, 1948

2,447,374

UNITED STATES PATENT OFFICE

2,447,374

METHOD OF APPLYING COATING MATERIALS

James S. Smyser, deceased, late of Quincy, Mass., by Granite Trust Company, executor, Quincy, Mass., assignor, by mesne assignments, to Behr-Manning Corporation, Troy, N. Y., a corporation of Massachusetts

Continuation of application Serial No. 721,388, April 25, 1934. This application October 18, 1939, Serial No. 301,294

3 Claims. (Cl. 117—93)

1

This invention relates to a method of applying particles and various forms of comminuted materials to a base member, and to the resulting product.

This application is a continuation of the copending application of James S. Smyser, Serial No. 722,388, filed April 25, 1934.

The principal objects of the invention are to provide a novel method for applying particles and finely divided materials, such, for example, as flock, linters, and the like fibrous material, abrasive particles, etc., to one or more surfaces of a base member, such as a piece of sheet material; to provide means for controlling the manner and rate of application or disposition of the particles so as to obtain a uniformly coated product having predetermined characteristics; and to provide means whereby unlimited lengths of sheet material may be coated efficiently and progressively, on either or both sides, more quickly, densely, uniformly and cheaply than by any apparatus and/or method heretofore used.

Other objects of the invention are to provide a strong and flexible product having a dense, homogeneous, villous finish simulating the appearance of either suede or a pile fabric; and to provide a finish of any desired density wherein the major portion of the fibers are disposed at substantially the same angle relative to the surface of the base sheet with their ends firmly embedded in an adhesive coating carried thereby.

Further objects relate to the mode of operation of the method, and will be apparent from a consideration of the following description and accompanying drawings which exemplify different embodiments of the invention.

In accordance with the present invention the surface (or surfaces) of the base member, or article to be coated is first rendered adhesive, as for example by the application of a suitable cementitious material, such as rubber cement, wax, paraffin, glue, or the like adhesive. When thus coated the base member is passed through an electrostatic field set up between one or more pairs of oppositely charged electrodes, and during its passage through the electrostatic field the particles to be applied are carried in a uniformly dispersed formation into the field either by gravity, a current of air, or in any other suitable manner.

Preferably the particles being conveyed to the field are charged in any suitable manner with the same charge as that of the electrode projecting them against the base member, and to this end they may be passed through a metallic

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screen or the like member which is connected in the circuit of the projecting electrode. When thus charged, the particles, upon entering the electrostatic field are projected against the adhesive surface of the base member more uniformly and efficiently, and with much greater force than would otherwise be possible. Furthermore, the individual particles are more effectively aligned in the direction of the lines of force of the electrostatic field and, due to the increased force with which they are projected against the surface of the base member, are more deeply and firmly embedded in the adhesive surface of the base member. Moreover, movement of the charged particles toward the adjacent or projecting electrode is greatly minimized, if not substantially eliminated, and consequently considerable waste is eliminated and the efficiency of the method and apparatus is appreciably increased.

The construction and arrangement of the electrodes is such as to provide an electrostatic field of uniform flux density which extends across the path of the surface of the article to be coated and at an angle to its path of travel. The position of the individual particles relative to the surface of the base member may be controlled and/or varied by adjusting the relative position of the electrodes so as to attain the desired direction of the lines of force of the electrostatic field relative to the surface of the base member. To this end one or both of the electrodes may be adjustably mounted so that their position relative to each other may be varied.

The electrostatic field may be produced by a suitable source of potential such as a Kenotron or the like alternating current rectifier, a static machine, mechanical rectifier, or any other source which may be susceptible to control. The potential impressed upon or across the electrodes may vary within wide ranges, depending upon the character of the material to be deposited, the desired rate of deposition, etc., and the usual types of control instrumentalities may be employed to provide an electrostatic field of the desired characteristics.

The rate of deposition or application may be so controlled as to produce a coated product of any desired density by varying the quantity of particles supplied, the rate of travel of the base member through the field, and/or the electrical characteristics of the field, i. e., the flux density, voltage across the electrodes, etc. To this end suitable means may be employed to control the rate of delivery of the particles and the rate of

travel of the base member, and appropriate devices such as rheostats and various types of impedances, together with the usual indicators (ammeters, voltmeters, etc.), may be connected in the electrical circuits or circuit to provide for the adjustments necessary to attain an electrostatic field suitable for the application or deposition of the particular type of material to be applied.

In the drawings:

Fig. 1 is a diagrammatic side elevation, in section, showing a suitable apparatus;

Fig. 2 is a diagrammatic plan view of the apparatus shown in Fig. 1, the means for feeding the particles to be applied being omitted;

Fig. 3 is a schematic diagram illustrating one arrangement of the electrical connections;

Fig. 4 is a graphic representation of a pulsating current used in connection with certain forms of apparatus herein shown;

Fig. 5 is a fragmentary section showing a piece of fabric before the application of an adhesive coating;

Fig. 6 is a fragmentary section showing the fabric after the application of the adhesive coating;

Fig. 7 is a horizontal view with parts shown in section of another modified form of apparatus;

Fig. 8 is a plan view of the apparatus shown in Fig. 7;

Figs. 9 and 10 are horizontal views, with parts shown in section of further modified forms of apparatus; and

Fig. 11 is an enlarged fragmentary section showing a specimen of sheet material after being coated in accordance with the present invention.

The embodiment shown in Figs. 1 and 2 comprises a coating apparatus 10, a deposition apparatus designated by the numeral 11, and a winding mechanism 12. The coating apparatus may be of any type suitable for applying a coating of adhesive such as rubber cement, wax, glue, paraffin, or the like cementitious material to one or both surfaces of a base member or sheet material 8, and as here shown comprises a tank or trough 10 having guide rolls 16, 17, 20, 21 and 22 to conduct the sheet material through a fluid bath 23 of suitable adhesive, and squeeze rolls 24 and 25 to remove excess adhesive and distribute the coating uniformly over the surfaces of the sheet 8. The temperature and fluidity of the bath 23 may be controlled in any suitable manner as by steam coils 26. The winding apparatus 12 may be of any conventional form and is here shown as comprising a guide roll 13, a winding drum 14, and a reel 15, upon which the coated sheet material is wound. Suitable means (not shown) may be provided to regulate the speed of the winding drum 14 and thus control the rate of travel of the sheet material 8.

The deposition apparatus 11 comprises a box-like structure or housing preferably having uprights or walls of suitable electrical non-conducting material which define the deposition zone or chamber 30, the top of which may be open as shown in Fig. 1. The end walls 31 and 32 are provided with vertically extending slots or openings 33 and 34, respectively, through which the sheet material 8 may be conducted into and out of the zone or chamber 30, and guide rolls 35, 36, 37 and 38 are provided to support the sheet 8 for movement along a predetermined path through the deposition zone or chamber 30.

Electrodes 40, 41, 42 and 43 are mounted in pairs, each electrode comprising an elongate metallic bar secured to a suitable support and having a series of pointed members or prongs secured thereto and arranged as shown in Fig. 2. The electrodes are arranged in pairs 40, 41 and 42, 43 and may be connected to any suitable source of potential as hereinafter described. The elements of each pair are disposed on opposite sides of the path of travel of the sheet 8 and are preferably inclined at an angle to its line of travel so as to provide an electrostatic field which extends diagonally across the path of movement of the sheet 8. The purpose of this inclined arrangement is to insure a more even coating when the comminuted material is fed to the electrostatic field from the top.

Suitable means are provided to conduct the material to be deposited on the sheet 8 into the electrostatic fields set up between each pair of electrodes and to this end hoppers 50 and 51 may be arranged directly above electrodes 40, 41 and 42, 43, respectively. If it be desired to coat one side of the sheet 8 only, the hoppers may be arranged to discharge the coating material into a zone between the projecting electrode and surface of the sheet to which the material is to be applied. Where both sides of the sheet 8 are to be coated, the hoppers may be arranged to discharge the particles on both sides of the sheet 8 or, if desired, one hopper may be arranged to discharge the material on one side of the sheet and the other hopper on the opposite side, the particular arrangement depending upon the connections of the electrodes for the most effective results.

At some convenient location between the hoppers 50, 51 and the electrostatic fields, there may be provided means for imparting an electrostatic charge to the particles to be applied and to this end metallic screens 52 and 53, or the like, may be mounted beneath the discharge openings of the hoppers 50 and 51, as shown in Fig. 1, or, if desired, these screens may be integral with the hoppers. Each of the screens are connected to the negative electrode or to the negative terminal of a suitable source of potential so that the particles as they emerge from the screens have the same negative charge as that of the negative or projecting electrode. Suitable means (not shown) may be employed to control the rate of delivery of the particles from the hopper so that the density of the coating applied to the sheet material may be varied as desired.

Fig. 3 shows how the electrodes may be connected for use with a pulsating current (graphically represented in Fig. 4) such as may be derived from a two-tube Kenotron rectifier, or a continuous (non-pulsating) current such as may be derived from a static machine, mechanical rectifier with a suitable condenser, a high voltage generator, or the like.

In the arrangement shown in Fig. 3, the electrodes 40 and 43 are connected to each other by a conductor 86 and by a conductor 84 to a suitable source of potential, here shown as a Kenotron rectifier designated generally by the numeral 60. The electrodes 41 and 42 are connected to each other by a conductor 87 and to the ground by a conductor 88. With this arrangement the conductors 86 and 84 are preferably connected to the negative terminal of the Kenotron 60 or other source of potential and its positive terminal may be grounded by means of conductor 88 or connected to the positive terminal of the source of potential, as desired. When thus connected the current flows from the Kenotron through a main circuit comprising the con-

duster 36, the ground and conductor 38, at which point the main circuit branches into two circuits, one of which comprises electrodes 43 and 45 and the conductor 36, the second branch circuit comprising the conductor 37 and electrodes 41 and 44. The conductor 36 connects the branch circuits to the negative terminal of the Kenotron and thus completes the main circuit from the Kenotron to the electrodes.

This arrangement is particularly suitable for use when both sides of the sheet S are to be coated as it will be noted that the negative or projecting electrodes 40 and 42 are on opposite sides of the sheet S and the intensity of the electrostatic fields established between each pair of electrodes is always the same. When this arrangement is used in conjunction with the apparatus shown in Figs. 1 and 2, the screens 32 and 33 may be connected to the electrodes 40 and 43, respectively, so that the particles discharged into the electrostatic field are first given a negative charge. The hoppers 30 and 31 and the screens 32 and 33 are preferably positioned so that the charged particles are delivered into that portion of the electrostatic field between the projecting electrode and the adjacent surface of the sheet to be coated.

In using the apparatus shown in Figs. 1 and 2 to carry out the process, the sheet material S, such as a piece of fabric 70 (Fig. 5), is drawn from the supply roll 18, through the bath 22 where a coating 71 (Fig. 6) of adhesive such as glue, paraffin, rubber cement, wax or the like is applied to both surfaces. While the adhesive coating is still tacky the sheet is guided between each pair of electrodes, as indicated in Figs. 1 to 3. The electrical connections are adjusted to produce the desired potential across the electrodes and thus establish an electrostatic field of the desired strength and intensity. After having made these adjustments the material to be applied is fed from the hoppers 30 and 31 at a predetermined rate and after passing through the screens 32 and 33 where the individual particles receive a negative charge, they are then carried by gravity into the electrostatic field. When material such as flock, linters and the like fibers, as well as the various forms of abrasive material such as Carborundum, pumice, tripoli, etc., constitute the coating material being applied, the individual particles upon entering the electrostatic field, due to their elongate nature, become aligned in the direction of the electrostatic lines of force and are uniformly projected or bombarded against the adhesive surface of the sheet S so that their ends are deeply and firmly embedded in the adhesive coating at substantially the same angle and their projecting portions are disposed in substantial parallelism relative to each other. Due to the initial charge imparted to the particles, they tend to repel each other and become dispersed so that upon being projected against the adhesive surface of the sheet S the individual particles are spaced relatively to each other. As the individual particles align themselves with their major axes coinciding with the direction of the electrostatic lines of force, they may be applied to the sheet S so that their major axes are disposed at any desired angle relative to the surface of the sheet and consequently a greater number of particles per unit area may be applied to the sheet and with greater uniformity than is otherwise possible. When thus applied, their embedded ends are held in spaced relation to each other on the sheet S and by reason of

capillary action and the removal of the film of air surrounding the particles the adhesive creeps up or rises along their sides forming a meniscus about the embedded ends of each individual particle.

After having received a coating of particles on one or both surfaces, sheet S is guided out of the deposition zone and passed between a pair of ultra-violet lights L and L' or other suitable means operative to discharge or neutralize the static charge carried by the coated surface without causing sparking. After removing the static charge on the sheet, it is then wound up on the reel 15. During both the coating and deposition operations the sheet S is held under slight tension by the "pull" of the winding drum and reel. The density of the coating may be varied, as desired, by varying either the rate of travel of the sheet S, the rate of delivery of the particles from the hoppers 30 and 31, or both, and the strength of the electrostatic field may be varied accordingly.

When applying fibrous material at a relatively low rate, a potential of the order of 15,000 to 25,000 volts may be used, although I prefer to use potentials from 100,000 to 500,000 volts, particularly where heavier particles are being applied or where the rate of application is to be greatly increased, the particular voltage depending upon the character of the particles, the rate of travel of the sheet, and various other operating conditions.

Figs. 7 to 10 show a form of deposition apparatus particularly suitable for the application of flock, linters, asbestos fiber, wood pulp fibers, fine abrasives and the like materials, to an adhesive coated surface of a base member. In the embodiment shown in Figs. 7 and 8 the sheet material S is drawn from the supply roll 80 over a spreader roll 81 provided with a spreader blade 82 which is operative to distribute a fluid or plastic adhesive 83, such as rubber cement or the like, uniformly over the surface of the sheet S. After having received a coating of adhesive of suitable thickness, the sheet is drawn over or about a guide member which constitutes a part of the deposition apparatus. Thereafter the sheet is drawn downwardly between a pair of discharging electrodes 84, 84 connected to a suitable source of high potential alternating current, then over a guide roll 86 and wound on a reel 87, as in the previously described apparatus.

The guide member preferably comprises a plate electrode 85 interposed between two sheets of electrical non-conducting material such as Bakelite, the upper sheet or layer 88 having a smooth surface and being provided with a rounded or beveled edge as shown in Fig. 7. The negative electrode 90 is disposed opposite the end of the electrode 85 and is arranged so as to establish a field whose lines of force intersect the path of travel of the sheet S at any desired angle. Preferably the length of each electrode is sufficient to provide an electrostatic field having a width corresponding to that of the sheet S.

A supply hopper 91 is disposed above the electrostatic field and is constructed and arranged to deliver the fibrous material onto a screen 92 or the like device interposed between the field and the hopper. The electrical connections are shown schematically in Fig. 7 wherein a conductor 96 connects the screen 92 and the electrode 90 to the negative terminal of a suitable source of potential designated by the numeral 98, the positive terminal being grounded by a conductor 97 or connected to the electrode 85, as desired.

The electrode 86 may be grounded by a conductor 96 or otherwise connected to the conductor 97, and suitable means such as a controller 98 and rheostat 100 may be provided to control the potential and flow of current in the circuit. If desired, a voltmeter 101 may be connected in the circuit in the usual manner. The electrodes 84, 84 when connected as shown in Fig. 7, establish an alternating electrostatic field across the path of the coated sheet and are thus effective to discharge or neutralize any static charge carried by the sheet. The operation of the apparatus is substantially the same as that of the previously described apparatus, it being understood that the present arrangement is designed to coat only one surface of the sheet S at one time.

In the embodiment shown in Fig. 9, the cementitious material is applied to the sheet S in the same manner as in the embodiment shown in Figs. 7 and 8. In place of the guide member and plate electrode shown in Figs. 7 and 8, a roller electrode 106 is used. The roller electrode provides a guide roll about which the sheet S is drawn on its way to the winding drum or reel (not shown) and may be connected to the ground or otherwise, as in the previously described apparatus. The negative electrode 107 comprises a metallic screen member which is shaped to provide a substantially horizontal portion 108 through which the particles discharged from the hopper 109 may pass, and a depending portion 110 disposed opposite but parallel to the roller electrode 106. The supply hopper 109 is disposed above the horizontal portion 108 of the negative electrode so as to discharge the particles onto its horizontal portion. The negative electrode is connected to the negative terminal of the source of potential and the usual control devices may be provided as in the previously described apparatus.

The embodiment shown in Fig. 10 is somewhat similar to that shown in Figs. 7 and 9 but is particularly designed for use in applying particles to a sheet having an adhesive coating which comprises a thermoplastic cementitious material, such as wax, paraffin, etc., which must be maintained in a relatively fluid or tacky condition during the deposition operation in order that the ends of the particles may be firmly embedded therein. The apparatus embodies all the essential elements shown in Figs. 7 to 9 but in place of the electrodes shown therein, a metallic block 114 and rotor 115 are used. The block 114 constitutes the positive electrode and preferably comprises a metallic casting having a series of longitudinally extending ducts or channels 116 which may be connected to a steam or hot water supply (not shown). The outer walls of the block 114 which contact with the sheet material are smooth and the adjacent corner is preferably rounded or beveled to provide a suitable guiding surface over which the sheet S is drawn. The rotor 115 constitutes the negative or projecting electrode and preferably comprises a cylindrical screen or grating supported on a circular plate which is rotatably mounted on a stationary tubular shaft 117. The tubular shaft 117 is provided with a suitably disposed axially extending slot coextensively with the lengthwise extent of the screen and facing away from the electrode 114. A conduit 118 having an elongated, horizontally extending, flaring mouth or entrance 120 disposed in sealed engagement with the slot 119, is disposed closely adjacent to the electrode 115, as shown, and may be connected to a suitable suction fan or the like (not shown). A supply hopper 122 and a charging screen 111 are provided as in the embodiment shown in Fig. 7 and similar electrical connections, controls and means for discharging the static charge from the coated sheet may be employed. During the deposition operation the electrode 115 is continuously rotated, compressed air being introduced into the shaft 117 and discharged through the slot 119, and the electrode 114 is maintained at a predetermined temperature by the flow of steam or hot water through the ducts 116. The force of the air striking against the screen or grating of the electrode 115 is sufficient to remove any accumulations of oriented fibrous material or other particles and carry them into the conduit 120, thus keeping the negative or projecting electrode relatively free of oriented material.

Fig. 11 shows a coated sheet material produced in accordance with the present invention. The backing sheet consists of a sheet of heavy paper 125 and the fibers of the coating 127 are adhered thereto by a layer of adhesive 126 and are disposed at an angle of 45° to 60° relative to the backing sheet 125, thus presenting an appearance resembling suede.

The products are greatly superior to those made in accordance with the prior practices wherein the fibrous material is deposited on an adhesive surface of a backing sheet by means of a current of air or by gravity. In such products the individual fibers are heterogeneously disposed on the surface of the adhesive and hence do not assume any definite position relative to each other. Consequently, such products do not possess the dense and uniform characteristics nor the attractive appearance or finish of those made in accordance with the present invention. Moreover, the wearing qualities of such products are greatly inferior to those made in accordance with the present invention due to the fact that the individual particles are not embedded to a sufficient extent, if at all, in the adhesive, and as the body portions and the ends of the individual fibers provide the surface of the product, the individual fibers are soon worn away or are easily dislodged from the adhesive and hence expose uncoated areas of the binder. In the products made in accordance with the present invention the individual fibers, being firmly embedded in the adhesive, are not easily dislodged and as their ends constitute the major portion of the surface of the product, they effectively resist wearing. Furthermore, due to the fact that a much denser coating may be applied to the adhesive surface of the backing sheet, there is a greater number of fibers per unit area to resist wearing and abrasion, and consequently the product of this invention will outwear those made in accordance with the prior practices.

While different desirable embodiments of the present invention have been shown, it is to be understood that this disclosure is for the purpose of illustration only and that various changes and modifications may be made without departing from the spirit and scope of the invention as set forth in the appended claims.

Certain phases of the invention are disclosed and claimed in the co-pending application Serial No. 370,632, filed January 22, 1941, which issued to Patent No. 2,297,277 on June 30, 1942.

What is claimed is:

1. The process of coating to provide a suede-like surface which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a surface thereof, and depositing on said

adhesive layer particles of finely divided fibrous material under the influence of an electrical field whose lines of force are directed so as to orient the particles with their major axes at an angle of from about 45 to 90° with respect to the backing, attaching the ends of said particles to said adhesive layer and leaving the opposite ends free, thereby forming the suede-like surface for said carrier or backing.

2. The process of forming suede-like surfaces which includes as steps thereof feeding a carrier or backing and applying an adhesive layer to a surface thereof, and depositing on said adhesive layer particles of flock under the influence of an electrical field whose lines of force are directed so as to orient the particles with their major axes at an angle of from about 45 to 90° with respect to the backing, attaching the ends of said particles to said adhesive layer and leaving the opposite ends free, thereby forming the suede-like surface for said carrier or backing.

GRANITE TRUST COMPANY,
By IRVING L. SHAW,
Vice President,
Executor of the Last Will and Testament of James S. Swayer, Deceased.

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The following references are of record in the file of this patent:

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[fol. 841]

IN THE UNITED STATES COURT OF APPEALS

FOR THE SEVENTH CIRCUIT

SEPTEMBER TERM, 1959—APRIL SESSION, 1960

No. 12737

BINKS MANUFACTURING COMPANY, ETC., Plaintiff-Appellant,

v.

RANSBURG ELECTRO-COATING CORPORATION, ETC., Defendant-Appellee.

Appeal from the United States District Court for the Southern District of Indiana, Indianapolis Division.

OPINION—July 27, 1960

Before SCHNACKENBERG, KNOCH and CASTLE, Circuit Judges.

CASTLE, Circuit Judge. Binks Manufacturing Company, plaintiff-appellant, prosecutes this appeal from a judgment of the District Court holding claims 1 to 6, 8, 10 and 11 of Starkey and Ransburg method patent No. 2,685,536 and Claim 4 of Starkey and Ransburg divisional apparatus patent No. 2,794,417 valid and infringed by use of the plaintiff's electrostatic spraying emitter. The judgment order enjoined plaintiff from further infringement, granted damages, reasonable attorneys' fees and costs to defendant, and dismissed plaintiff's cross-counterclaim alleging anti-trust law violations by defendant. Ransburg Electro-Coating Corporation, defendant-appellee, is the assignee-owner of both patents.

The action originated in the District Court as a complaint for declaratory judgment which was dismissed as [fol. 842] moot when the defendant patentee counterclaimed charging plaintiff with infringement. Plaintiff's answer raised the issues of validity and infringement and its cross-

counterclaim charged anti-trust law violations, unfair competition and misuse of patents. Substituted pleadings retained the same issues. The cause was heard on the pleadings, stipulations, admissions, answers to interrogatories, depositions, exhibits and the testimony of witnesses for the defendant.

The parties will be referred to by their original designations as plaintiff and defendant. Defendant is the patentee asserting infringement. Plaintiff is defending against that charge and affirmatively asserting anti-trust law violations.

The patents in suit relate to a method and apparatus for electrostatically coating articles with liquid coating material, including paint. There are several methods by which many articles of manufacture may be painted, including dipping, roller-coating, flow-coating and spraying. Defendant (and the predecessor partnership composed of its owners) has developed two methods of electrostatic coating. A compressed-air electrostatic system is referred to as the No. 1 Process. The patents in suit relate to an airless electrostatic system referred to as the No. 2 Process. During the year 1957 the total cost of all paint, varnish and lacquer used industrially in the United States approximated 644 million dollars. Approximately one per cent was applied by defendant's No. 2 Process and 0.6% by defendant's No. 1 Process.

In the No. 1 Process the paint is sprayed by means of compressed-air spray guns into an electrostatic field which is maintained between wires or electrodes and the conveyorized articles of manufacture so that paint particles are electrostatically charged and urged toward deposition upon the articles by the effect of the field.

In the No. 2 Process, the airless system to which the patents involved relate, the electrostatic field is maintained directly between an atomizing device and the articles on the conveyor. The liquid coating or paint is fed at a controlled rate to and distributed along the extended edge of a stationary or a rotary atomizing head. The strength of the electrostatic field at the edge is such that [fol. 843] the field is capable of electrostatically atomizing fine electrically charged particles from the liquid. The field

disperses these particles in the form of a spray and deposits them upon the articles to be coated. Patent No. 2,685,536. is upon the method employed in such airless electrostatic coating or spray-painting and patent No. 2,794,417 is upon the apparatus employed therein. The method and device electrostatically effect atomization, dispersion and deposition in combination and under control.

The No. 1 Process reduced coating material losses due to over-spray but in many instances considerable loss persisted because the electrostatic field only partially counteracted the tendency of the compressed-air blast to carry the coating material elsewhere than to the articles to be coated or painted. The No. 2 Process eliminated the necessity of compressed-air spray guns to atomize the coating materials. In many applications it virtually eliminated over-spray, and thus paint loss or waste. It reduced labor costs for clean-up operations and substantially reduced the manufacturer's investment in spray booths, exhaust systems and related equipment.

The District Court made 94 detailed findings and 11 conclusions of law. The evidence included testimony of defendant's witnesses, including expert testimony. Consequently, insofar as the findings concern factual issues such as the use made of prior art, and the nature of the improvement made over prior art, Rule 52 (a) Federal Rules of Civil Procedure, 28 U.S.C.A. applies. The scope of our review is thus limited to a determination of whether such findings are "clearly erroneous". *Armour & Co.* v. *Wilson & Co., Inc.*, 274 F. 2nd 143, 156. If they find support in the evidence we are bound thereby.

The errors relied upon by plaintiff arise out of the District Court's findings and conclusions and its exclusion of certain evidence offered by plaintiff.

Plaintiff contends the patents are invalid for lack of invention over prior art; that the court's finding of commercial success was error because the stationary electrostatic atomizing heads shown and described in the patent were never commercialized; that the method claims in suit fail to set forth a patentable invention; that Claim 4 of the apparatus patent is invalid as constituting double [fol. 844] patenting; that representations of commercial

success made to the patent office were false and the patents procured were therefore a fraud on the public and unenforceable; and that Claim 4 of the apparatus patent is invalid because of public use.

Prior art relied upon by plaintiff includes a description of a procedure referred to as "spinning sealing wax" in an 1859 publication entitled "Electrical Experiments" by one Francis; an 1887 article by C. V. Boys describing an experiment characterized as "electrical spinning"; 1915 and 1917 articles by Professor John Zeleny concerning the effect of electrical current on surface points of liquids and the instability of electrified liquid surfaces; Littlefield patents Nos. 1,360,654 and 1,854,475; Darrah patent No. 1,958,406; Gravley patent No. 2,359,476 and Heis patent No. 1,475,995.

The Francis and Boys articles disclose nothing more than laboratory experiments demonstrating that an electrostatic field could form threads or fibers from molten wax or other viscous material. Zeleny disclosed laboratory demonstrations of the fact that an electrostatic field is capable of exerting atomizing action from liquid surfaces. These references disclose action due to electrostatic forces. They neither disclose nor suggest the combination of steps or elements which endows defendant's method and apparatus patents with novelty and which adds to the source of useful knowledge. The Littlefield patents, at most, disclose electrostatic atomization, and like the Darrah reference which, in addition, shows projection of the atomized liquid by electrostatic force, they contain no suggestion of a spray-receiving object to attract the particles. Nor was defendant's electrostatic de-tearing process described in the cited Gravley patent suggestive of either a method or a device to apply a coating. Gravley discloses the use of electrostatic force to remove an excess of coating. In that process an article coated, as by dipping, with an excess of liquid coating material is partially drained and then brought into association with an electrostatically charged grid. The "tears" of excess liquid at the bottom of the article are attracted to the grid by electrostatic force and leave the article. The Heis patent deals with a method and apparatus wherein gaseous substances are

passed through an electrostatic field to promote chemical reaction. It suggests nothing useful in the field of the [fol. 845] patents here challenged. That plaintiff's accused device uses an atomizing head similar to the conductive disks disclosed by Heis does not have the effect, as plaintiff seems to urge, of suggesting defendant's novel adaptation of electrostatic atomization, dispersion and deposition to the field of spray-coating or spray-painting. None of the prior art teaches nor suggests the combined atomization, dispersion and deposition of coating material through utilization of electrostatic force.

Defendant's patents are combinations of old elements in a novel manner productive of new and useful results. The District Court was not in error in finding the defendant's method and apparatus patents impregnable as against the cited references to prior art, nor in finding they constituted a broad and basic invention. The evidence substantially supports the District Court's factual findings and it applied the correct criteria of invention. *Leeds & Catlin Company* v. *Victor Talking Machine Co.*, 213 U.S. 325, 332; *Lewyt Corporation* v. *Health-Mor, Inc.*, 7 Cir., 187 F. 2d 855, cert. den. 340 U.S. 823; *Great Atlantic & Pacific Tea Co.* v. *Supermarket Equipment Corp.*, 340 U.S. 147, 152.

The District Court's finding of commercial success was not "clearly erroneous". It was well supported by the evidence. Such a finding is not of itself determinative of the issue of invention. It cannot lend validity to a patent where invention is plainly lacking. *Goldman* v. *Bobins*, 7 Cir., 245 F. 2d 840, 844; *Great Atlantic & Pacific Tea Co.* v. *Supermarket Equipment Corp.*, 340 U.S. 147, 153. But, although not of itself decisive, commercial success is a factor which should not be ignored. *University of Illinois Foundation* v. *Block Drug Co.*, 7 Cir., 241 F. 2d 6, 11; *Technical Tape Corp.* v. *Minnesota Mining & Manufacturing Co.*, 2 Cir., 247 F. 2d 343, 348, cert. den. 355 U.S. 952.

The specific atomizing heads shown in the specifications of defendant's method and apparatus patents utilize spaced needles, spaced orifices, or spaced wire wrappings. The liquid emerging from the interior of the head is thus mechanically divided into droplets from which the atomization takes place. The defendant's commercial atomiz-

ing device utilized a rotating bell or rotating disk through which the liquid coating is fed and at the edge of which atomization takes place at a plurality of closely spaced points. However, neither the claims of the method patent [fol. 846] nor of the apparatus patent are limited to feeding the liquid through a plurality of orifices or points of separation obtained mechanically or structurally. And the claims not the drawings define the invention. *American Anode, Inc.* v. *Lee-Tex Rubber Products Corp.*, 7 Cir., 136 F. 2d 581. The variance in structure employed in the commercial atomizing head is not indicative that the commercial success enjoyed is not attributable to the method and apparatus patent. The revolving bell or rotating disk feeding the paint to the atomizing zone by centrifugal force is fully embraced within the general concepts of the invention and constitutes a mere improvement in the mechanics of presenting the liquid to the zone of atomization.

And what has been said in this connection on the subject of commercial success also disposes of plaintiff's contentions that because of the difference between the atomization heads shown in the drawings and those utilized in defendant's commercial system a fraud was practiced on the Patent Office in the representations made with respect to commercial success and that the alleged fraud is indicative of defendant's purpose "to monopolize wrongfully the entire field of electrostatic coating on false affidavits."

We find no merit in plaintiff's contention that the method claims fail to satisfy the requirements of the patent statute (35 U.S.C.A. §112) because they merely cite a desired result rather than the means for producing the same, and because of incompleteness due to failure to specify voltages, spacing, and liquids to which they are applicable. The process claims define the specific steps of procedure and the specifications being addressed to those skilled in the art (*Highway Appliance Co.* v. *American Concrete Expansion Joint Co.*, 7 Cir., 93 F. 2d 713) need not recite details. The pertinent portion of the statute provides:

> "An element in a claim for a combination may be expressed as a means or step for performing a speci-

fied function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material or acts described in the specification and equivalents thereof."

[fol. 847] There is no requirement that quantitative values for such factors as voltage, spacing and liquid characteristics be recited. The fact that experimentation or the exercise of judgment is necessary to adapt a patented process to particular material or to obtain the particular results desired does not impair validity of the patent. *Lever Bros. Co.* v. *Procter & Gamble Mfg. Co.*, 4 Cir., 139 F. 2d 633, 638-639.

Nor does the fact that there are liquid coating materials which cannot be used in an airless electrostatic spray-coating system make defendant's claims broader than its invention. The invention is not overclaimed in being directed broadly to liquid coating materials. The liquids are the materials upon which the process acts—not the active agent. Plaintiff's reliance on *Graver Tank & Manufacturing Co., Inc.* v. *Linde Air Products Co.*, 336 U.S. 271 is ill-placed. There the fluxes were claimed and included some inoperative to provide the desired feature. The method patent here involved does not purport to claim or extend to the liquid coating materials upon which it operates.

Plaintiff asserts that Claim 4 of the apparatus patent is invalid as constituting double patenting. Its argument is predicated upon the common disclosures of Claim 1 of the method patent and Claim 4 of the apparatus patent with respect to a plurality of points "spaced to form a substantially continuous extended atomizing zone" and being "sufficiently close together to permit the coating material to bridge the spaces therebetween" and defendant's witness Miller's testimony that "in order to form a continuous atomizing zone bridging is necessary so that you will get continuous and uniform feeding to the various atomizing points or sites." But it is entirely proper to cover the same disclosure by two patents co-pending, one for the method and the other for the apparatus. *General*

Tire & Rubber Co. v. *Fisk Rubber Corp.*, 6 Cir., 104 F. 2d 740, cert. den. 308 U.S. 581. Nor do the patents in suit involve double patenting of the subject matter of Ransburg patent No. 2,658,009. The latter covers a different feature, the use of an additional electrode to "shape" a spray, and in any event has a filing date later than the patents in suit.

[fol. 848] The amendment of Claim 4 in 1956, while the apparatus patent was pending, to include a reference to the "bridging" feature was not insertion of new matter in departure from the original applications in violation of 35 U.S.C.A. §132. The "bridging" was inherent in what the original applications disclosed. The District Court's findings as to the bridging feature are supported by the record. There is evidence that the atomizing head utilizing spaced needles provided a series of gutters between adjacent needles fed with liquid through openings present between the contacting needles, the plate and the wall of the device; that liquid or paint in the gutters would divide between the droplets formed at the tip of the needles and in so doing form a continuous web or film bridging the space.

Muncie Gear Works, Inc. v. *Outboard Marine & Mfg. Co.*, 315 U.S. 759, 768, cited by plaintiff, is not applicable. In the instant case the original application disclosed the basis for the amended claim and there is no evidence of public use more than one year before the invention was first presented to the Patent Office.

Prior to the submission of the amendment to Claim 4 plaintiff had sent a drawing of its accused device to the defendant in connection with negotiations concerning licensing. The District Court's finding that the amendment to Claim 4 was not the result of any disclosure of plaintiff's device, but was an earlier and independent development is supported by the evidence.

Plaintiff's accused method and apparatus employ a stationary electrostatic emitter, the atomizing head of which has two coaxial concentric disks spaced about 0.007 inches apart, having a knife edge at each periphery, presented edgewise to the article. Liquid coating material or paint is supplied at a controlled rate near the center of the disks. It is formed into a film in the space between the

disks and flows outward to the periphery. A spacer or shim between the disks confines the liquid film to a portion of the disk circumference. At the periphery of the disk the field draws the edge of the film into a series of closely spaced cusps and atomizes finely-divided electrically charged particles from the tips of the cusps. The field disperses the atomized particles and deposits them on the grounded article. No mechanical means is provided for spacing the cusps.

[fol. 849] While in all the specific embodiments of the method and apparatus disclosed in the patents in suit the liquid emerges from the interior of the atomizing head through a plurality of orifices and is mechanically divided or concentrated into droplets from which the atomization takes place, the method claims are not limited to feeding the liquid through a plurality of orifices or to its concentration into droplets. Nor is Claim 4 of the apparatus patent limited to an atomizer which has a plurality of feed orifices or mechanical provisions for concentrating the liquid into droplets. The District Court's finding of infringement is supported by the testimony of defendant's expert witness concerning the features of the accused device as compared to the claims of the patents in suit. Plaintiff bases its case for non-infringement on the absence from its emitter of any physical or mechanical points. That argument fails because the claims in suit are not limited to a system including physical or mechanical points. Plaintiff's system employs the principle of the patents in suit, appropriates the substance of the invention as defined in the claims, does the same work in the same way, and accomplishes the same result. The slight change in form does not avoid infringement. The fact that there are structural differences between plaintiff's emitter and the heads specifically shown in the patents in suit is without significance in respect to infringement of the method patent. Infringement of a method patent is not dependent on the form of apparatus used. *Cochrane* v. *Deener*, 94 U.S. 780, 787-788. It is not material whether the means employed, the extended edge of the atomizer head, has physical points or is an uninterrupted edge.

On the patent branch of the case we conclude that the District Court's findings of fact are supported by the record, including expert testimony, and are not clearly erroneous. And, the District Court's conclusions of law with respect to validity and infringement are applications of correct legal criteria.

Plaintiff's cross-counterclaim alleged violation of Sections 1 and 2 of the Sherman Act (15 U.S.C.A. 1 and 2), and Section 3 of the Clayton Act (15 U.S.C.A. 14). Plaintiff's contention that the District Court erred in the dismissal of its cross-counterclaim is predicated on charges [fol. 850] that the District Court erroneously found and concluded that the defendant had not misused the patents in suit by reason of having combined licenses thereunder with leases of equipment and by not identifying the particular patents in the license agreements; that a cross-licensing agreement between defendant and another manufacturer was not for an unlawful purpose and its performance not a misuse of patents, nor in violation of the anti-trust law provisions, nor a damage to plaintiff; that a discontinued license-back provision in defendant's early license agreements did not constitute anti-trust law violation; and that patent procurement activities of the defendant did not violate the anti-trust law provisions.

On the record it had before it we cannot say there is clearly error in the District Court's finding and conclusion that plaintiff's domination of the airless electrostatic spraying system market is solely by virtue of the monopoly created by its patents and has not been extended or enlarged beyond its proper scope. The evidence supports a conclusion that plaintiff failed to establish that defendant has engaged in any activity beyond the exercise of rights incident to its patent monopoly.

The record establishes that defendant does not sell equipment outright nor has it licensed anyone to make and sell electrostatic spray coating systems. Although defendant offers license agreements containing a lease of equipment the leasing arrangement is not imposed as a condition of licensing and licenses are available without equipment being leased from the defendant. The combined license-lease arrangement was therefor not illegal nor a

misuse of patents under the Clayton Act. *Cf. Linde Air Products Co.* v. *Graver Tank & Mfg. Co.*, 7 Cir., 167 F. 2d 531, 539. Although the record discloses that customers preferred the license-lease arrangement it is not indicated that such preference was due to defendant's insistence. Nor did the evidence concerning the difference in consideration paid require a finding that it was a compelling factor. That defendant furnished replacement parts without additional charge where the licensee leased equipment does not, on the facts here involved, evidence a Clayton Act or other anti-trust law violation. *Cf. Stearns* v. *Tinker & Rasor*, 9 Cir., 252 F. 2d 589, 604. The monopoly of defendant's patents was not extended by the agreement to articles or supplies not covered by the patent.

[fol. 851] The license agreement does not identify specific patents but grants a right to use an identified process for coating particular items in accordance with a system identified by a drawing. No licensee pays for or receives any license under a patent not applicable to the system. The licenses are terminable by the customer on thirty days notice. It does not appear that any attempt is made to extend a patent monopoly beyond the life of the patent, nor is the issuance of a license to use the system covered by the patents in suit conditioned on the acceptance of licenses under unwanted patents. No prohibited "package licensing" is involved. *Apex Electrical Mfg. Co.* v. *Altorfer Bros. Co.*, 7 Cir., 238 F. 2d 867, 871; *Automatic Radio Mfg. Co. Inc.* v. *Hazeltine Research, Inc.*, 339 U.S. 827.

Defendant's cross-licensing agreement with Behr-Manning does not purport to embrace the patents in suit and the evidence establishes no direct damage to plaintiff's business or property as a result thereof. Relief under plaintiff's cross-counterclaim cannot be predicated on the cross-licensing agreement. *Blaski* v. *Inland Steel Company*, 7 Cir., 271 F. 2d 853, 854-5. It is unnecessary that we consider the specific findings made by the District Court as to its validity or effects otherwise.

Between 1951, when defendant began to market its No. 2 Process on a commercial scale, and 1955 the license agreement contained license-back provisions requiring that future inventions by the licensee pertaining to method

and apparatus for electrostatic atomization of liquids or to coating with electrostatically atomized liquids, be licensed to defendant royalty-free, on a nonexclusive basis, with the right to sub-license. The license-back provisions were eliminated from defendant's license forms in 1955. Defendant obtained no licenses from any of its licensees pursuant to the clause and the effect of the clause on the incentive of licensees to make improvements is purely conjectural. A license-back clause is not illegal *per se*. *Transparent-Wrap Machine Corp.* v. *Stokes & Smith Co.*, 329 U.S. 637. Unlike the situations condemned in *United States* v. *General Electric Co.*, 80 F. Supp. 989 and *United States* v. *General Electric Co.*, 82 F. Supp. 753 there is no wide-spread network of such agreements between competing companies affecting an entire industry.

[fol. 852] Plaintiff's contention that the representations made by defendant to the patent office in the procurement of the patents in suit were false has been considered in connection with the arguments addressed to the question of commercial success. It is apparent that the representations did not evidence a purpose to "monopolize wrongfully the entire field of electrostatic coating on false affidavits" in violation of anti-trust law prohibitions as urged by plaintiff.

Plaintiff asserts error based on the District Court's ruling excluding from evidence, on defendant's objection, a certified copy of a consent judgment in an action brought by the United States against the Behr-Manning Corporation and certain other manufacturers charged with conspiring by means of patent agreements to monopolize commerce in coated abrasives. This consent decree did not find or adjudicate that the agreement between defendant and Behr-Manning was a violation of anti-trust law or otherwise unlawful, and neither that agreement nor the defendant was involved in any way in that action. It was an agreed judgment not in any way binding on defendant. The defendant was neither a party nor a privy to the action. There was no error in rejecting the proffered decree.

The other claimed error relating to exclusion of evidence concerns the District Court's ruling in sustaining

defendant's objection to the admission of one answer in a deposition. The answer was a voluntary statement of the witness of a conclusion, and not being within the field of expert opinion by one qualified to testify in such field, was clearly not admissible. The ruling was not error.

The District Court's allowance of attorneys' fees to defendant is not predicated on any specific finding as to the basis for such an award. Allowance of such fees should find support in a specific finding as to the exceptional circumstances justifying the award. *Apex Electrical Mfg. Co.* v. *Altorfer Bros. Co.*, 7 Cir., 238 F. 2d 867, 874. From our review of the record we are of the opinion that the facts do not justify a conclusion that there is herein presented the "exceptional case" in which attorney's fees are allowable under 35 U.S.C.A. §285. Plaintiff has long been in the spray-painting equipment [fol. 853] business. The controversy which precipitated the action appears to have been *bona fide*. See *Anderson Company* v. *Sears, Roebuck and Co.*, 7 Cir., 265 F. 2d 755. Plaintiff's negotiation for a license and its reluctance to supply the accused device without an indemnification agreement from the prospective customer indicate only business prudence similar to that exercised by defendant in its original acquisition of certain patents and in obtaining the cross-licensing agreement with Behr-Manning. 'It was the defendant who converted the declaratory judgment proceeding into a patent infringement suit at a time when the whole basis of the infringement charge was a single unit built by plaintiff and used by it experimentally and for demonstration purposes, none having been sold by plaintiff. It is our conclusion that the District Court's allowance of attorneys' fees was, on the facts presented, an abuse of discretion.

Plaintiff filed a motion in this Court to vacate the District Court's judgment and remand the cause for consideration of newly discovered evidence in the form of two patents issued to defendant subsequent to the appeal to this Court. Plaintiff relies on the provisions of Rule 60 (b) of the Federal Rules of Civil Procedure (28 U. S. C. A.). The motion was taken with the case by order entered August 14, 1959.

When an appeal from a judgment is pending a motion under Rule 60 (b) for relief from the judgment because of newly discovered evidence, should be filed in the district court and that court should proceed to hear the motion. If the district court indicates that it will allow the motion the court of appeals should then be requested to remand the cause. This procedure was followed in *Zysset* v. *Popeil Bros. Inc.*, 7 Cir., 276 F. 2d 354 where we remanded for consideration of alleged newly discovered evidence on the District Court's certification that there appeared to be sufficient cause at law to warrant reopening of its judgment pursuant to Rule 60 (b). See also *Ferrell* v. *Trailmobile, Inc.*, 5th Cir., 223 F. 2d 697, 698-9; *Smith* v. *Pollin*, D.C., 194 F. 2d 349, 350 and 7 Moore's Federal Practice, 2d Ed. 336, Par. 60.30 (2).

Apart from the fact that plaintiff's motion is not properly addressed to this court it is predicated upon arguments with respect to the scope of the claims in suit similar [fol. 854] to those which we have found unsound in considering plaintiff's appeal. The subsequently issued patents cover the commercial form of the defendant's equipment. Their validity is not here in issue. They are at most improvements on the patents in suit. The evidence relied upon as newly discovered would not in our opinion have affected the judgment of the District Court.

The judgment of the District Court is affirmed in all respects except insofar as it allows attorneys' fees to defendant. It is reversed as to the allowance of attorneys' fees.

AFFIRMED IN PART AND REVERSED IN PART.

[fol. 855]

IN UNITED STATES COURT OF APPEALS

FOR THE SEVENTH CIRCUIT

Before Hon. Elmer J. Schnackenberg, Circuit Judge; Hon. Wm. G. Knoch, Circuit Judge; Hon. Latham Castle, Circuit Judge.

No. 12737

BINKS MANUFACTURING COMPANY, etc., Plaintiff-Appellant,

vs.

RANSBURG ELECTRO-COATING CORPORATION, etc., Defendant-Appellee.

Appeal from the United States District Court for the Southern District of Indiana, Indianapolis Division.

JUDGMENT—July 27, 1960

This cause came on to be heard on the transcript of the record from the United States District Court for the Southern District of Indiana, Indianapolis Division, and was argued by counsel.

On consideration whereof, it is ordered and adjudged by this court that the judgment of the said District Court in this cause appealed from be, and the same is hereby, Affirmed, with costs, in all respects except insofar as it allows attorneys' fees to defendant. It is Reversed as to the allowance of attorneys' fees, in accordance with the opinion of this Court filed this day.

[fol. 856] Clerk's Certificate to foregoing transcript (omitted in printing).

[fol. 857]

SUPREME COURT OF THE UNITED STATES

No. 501, October Term, 1960

BINKS MANUFACTURING CO., Petitioner,

vs.

RANSBURG ELECTRO-COATING CORPORATION.

ORDER ALLOWING CERTIORARI—December 19, 1960

The petition herein for a writ of certiorari to the United States Court of Appeals for the Seventh Circuit is granted.

And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.